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REVIEW OF EIGHT ARMY SYSTEMS: CHARACTERISTICS AND IMPLICATIONS FOR EMBEDDED TRAINING

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This research note reviews eight Army systems and attempts to relate their system characteristics to the opportunities and requirements for development of embedded training (ET) in current and future Army systems. This is an early step in a major Army Research Institute program to develop formal and systematic procedures (to be included in the LCSMM acquisition process) to identify ET needs, to determine how and when ET should be included, and to define the procedures which will assist systems and training developers in the (OVER)

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19. Abstract (continued)

implementation of ET in their systems.

Characteristics of the following eight Army systems were reviewed: four fielded systems (Apache AH64A, Bradley M2, Patriot ADA System, and TACFIRE [an FA tactical fire direction system], and four systems in development (AFTADS [the successor system to TACFIRE], ASAS I/EW ADP System, Aquila RPV, and the HIP [Howitzer Improvement Program].

Characteristics of the systems which were reviewed included: system-mission-equipment; personnel and operator-maintainer tasks; computational capability; simulation capability; training ~~[both~~ institutional and unit training, with an emphasis on ET where it does or could exist]; feedback and assessment of performance; availability of system and personnel for training; training problems; and training costs. (Little data on costs, and essentially no data on cost effectiveness were collected, although the questions are considered in the report.)

The analysis was directed toward derivation of implications for the development of the implementation procedures and guidelines mentioned above. The discussion and conclusions provide directions for such guidelines, as well as some specific guidelines.

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FOREWORD

The Army has recently begun to use embedded training capabilities as a component of sustainment training systems to improve soldier performance in units. These early implementations of embedded training have raised some critical questions, including: what factors make an embedded training package effective and cost effective; when should an embedded training package be incorporated into what kinds of systems; how should such packages be developed within the Army's acquisition process; and, how can they be effectively implemented within the paradigm for training and evaluation.

The Army Research Institute (ARI), in partnership with the Project Manager for Training Devices (PM-TRADE), has initiated a research program into these and related questions. The program will lead to procedures for systems developers to follow in the consideration, design and development of embedded training components of training systems. The procedures and guidelines will assist the determination of when embedded training should be used, how it can be best implemented and how its development must mesh with the requirements of the systems acquisition process, the Life Cycle Systems Management Model (LCSMM).

This review of the characteristics of eight Army systems and their training systems is an early step in a research program to define and institutionalize the processes necessary to assure adequate consideration, and appropriate inclusion, of embedded training in Army systems, fielded and developing.

REVIEW OF EIGHT ARMY SYSTEMS:

CHARACTERISTICS AND IMPLICATIONS FOR EMBEDDED TRAINING

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REVIEW OF EIGHT ARMY SYSTEMS:

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EXECUTIVE SUMMARY

Requirement

To examine characteristics of Army systems (including training systems) and develop information necessary to:

* identify equipment and Soldier performance characteristics related to requirements for and effectiveness of embedded training (ET):

* identify successful and unsuccessful training in systems;

* determine indicators of need for and probability of success of ET;

* develop guidelines and hypotheses about:

  - what facilitates or negates training success, with emphasis on ET; and,

  - how to implement facilitating characteristics in systems

Approach

A comprehensive review of Army systems was impossible within the limited resources. Therefore, we selected eight Army systems believed to have high potential for providing insights to relationships between systems characteristics and the embedded training questions. These systems were also likely to yield a broad range of information, since they comprised a wide range of system types and branch activities.

Thus, the review was designed to gather the maximum amount of information from a limited number of systems varying across Army system types, branch activities, personnel performance requirements and stages of development. Four fielded and four developing Army systems were reviewed. For each system, staff members reviewed systems' characteristics by means of observation and interviews with Program Managers, TRADOC Systems Managers, training developers, combat developers and units. Additionally, all available systems' documentation was reviewed.

The analyses compared and contrasted systems' data on equipment, mission, personnel and task requirements and current or proposed training systems for the eight systems. This allowed documentation of information on training successes and failures (ET and otherwise) and derivation of appropriate implications for embedded training possibilities. This was an information gathering process which yielded data for relating system characteristics to embedded training developmental needs.

Findings

The product of this review is a selective database of systems' information which will serve as input to the development of guidelines for ET implementation and hypotheses for further development of ET approaches.

Within the range of the data collected, several conclusions were stated. However, data must be obtained from other similar systems to validate these statements. The more general conclusions are:

1. Army training systems vary widely on the degree of integration of training packages into the total system. The continuum ranges from standalone training packages (primarily institutional) and training devices/simulators (institutional and unit) through strap-on training devices (sometimes resembling ET - mainly unit) to fully integrated embedded training based on software alone (unit, but also used in institutions).

2. ET packages also vary on degree of comprehensiveness, adequacy of instructional techniques and adequacy of feedback.

3. System types likely to be appropriate for embedded training are computer based or supported systems and systems requiring mostly cognitive vs. psychomotor tasks.

4. Cognitive decision making and other highly perishable tasks pose greater requirements for embedded training.

5. Very early consideration of embedded training is needed for systems which may require strap-ons, since more system modification will be required to accommodate embedded training.

6. Embedded training is important to training effectiveness when perishability of skills to operate equipment is a critical factor in operational readiness, and when job site sustainment training is necessary.

7. Embedded training should be considered in the LCSMM as early as humans are seen as potential operators of the system. The critical sustainment training of operator skill through embedded training may be the most important factor in whether a system with embedded training is even feasible.

Utilization of Findings

Information developed will be combined with data from two related reviews (Massey, D., Downes-Martin, S., Harris, M. & Kurland, L., 1985: and, Harris, C. B., Shipton, D. L. & Bogner, M. S., 1985) as the basis for preliminary guidelines for systems developers in considering and implementing ET in Army systems. The combined data set will also be used to generate hypotheses about procedures for design, development and implementation of ET packages in Army systems.

Even without full support, these data should be considered by training system developers in the selection, design and development of embedded training in Army systems.

Research Note

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REVIEW OF EIGHT ARMY SYSTEMS:

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This review of the characteristics of eight Army systems and their training systems is an early step in a research program to define and institutionalize the processes necessary to assure adequate consideration and appropriate inclusion of embedded training in Army systems, fielded and developing. The research is being conducted by the Army Research Institute (ARI) with the co-sponsorship of PM-TRADE (Project Manager for Training Devices).

This review is a part of the data gathering process necessary to develop the basis for the rest of the project. The total process is to identify the technological capabilities available and used for embedded training in Army systems and to derive implications and hypotheses related to ET potential for Army systems. As such, this task is the initial R&D step in the embedded training project: it is the search for what has been done with ET, what can be done with ET and what should be done with ET in Army systems. This search and information gathering process is being conducted through three separate reviews and will be completed by a fourth effort to summarize and correlate the information and derive implications for the ET development process. The three review projects are:

1) A technology review (Massey, D., Downes-Martin, S., Harris, M. & Kurland, L., 1985) - to determine what is possible in terms of both instructional technology and the equipment/software to support it;

2) A review of ET in Tri-service systems (Harris, C. B., Shipton, D. L. & Bogner, M. S., 1985). - to identify the current state of the art in ET application to military training systems; and,

3) A review of Army systems - to examine a selected set of Army systems to determine the potential scope of ET application and identify those system characteristics which could serve as decision and design criteria for potential ET applications.

The fourth effort (the "crosswalk") will integrate the information obtained from the three review projects and produce two kinds of outputs:

1) conclusions to be developed into tentative ET applications guidelines and preliminary specifications; and,

2) hypotheses about ET potential or applications approaches, etc., which can be tested in the continuing research project.

Purpose

The major purpose of this review, then, was to examine Army systems' major characteristics, requirements for soldier task performance and other factors, in relation to the requirement for (and effectiveness of) ET. This was to lead to the definition of those characteristics, including task performance requirements and training applications, that would define systems and training systems most likely to benefit from inclusion of an embedded training component. The analysis was also to relate system characteristics and task type to the training technology used for the ET device or other training

devised to meet the training requirements. Both of these sub-goals were aimed at the eventual development of decision and design criteria for ET implementation in Army systems.

A subsidiary purpose of the review was to describe existing Army ET components and to examine the development and implementation of such systems. This amounted to the need for a general assessment of the effectiveness of the embedded training implementation in those systems where ET was found. Meeting this purpose led the study staff to identify some needed improvements in ET where it already existed and some ET requirements in systems where it was not programmed. Thus, in the course of the review, HSI staff members observed and reported some potentially needed changes or elaborations of ET specifications for developing systems where ET already was a requirement. Similarly, the study staff detected requirements for ET in fielded systems without ET and in developing systems without currently recognized ET needs. Suggestions related to such needs were provided to program personnel as appropriate and are discussed in the separate system reports.

As indicated above, the long range purpose of this and the related research efforts is to develop the basis for determining where, when and how the consideration of ET should be integrated into the Life Cycle System Management Model (LCSMM). This effort is based on the belief that such integration is essential to the adequate and early consideration of ET in the development of future Army training systems. Integration of these considerations into the LCSMM and the actual systems acquisition cycle will insure that:

1) those system design decisions necessary for effective training system development are made early; and,

2) therefore, expensive systems modifications will not be required to optimize training.

Scope of Review

This report describes the conduct of the review of Army systems and presents results and conclusions. The intent of the review was to ascertain the general characteristics of a range of Army systems and to try to identify those characteristics which might be most indicative of probable need for, and success of, embedded training (ET) in Army systems. Because of this intent and the limited resources available, it was determined that the review could not be comprehensive of Army systems, nor even representative in the statistical sense. Rather, the review needed to concentrate on systems likely to provide the best potential for insights to relationships between system characteristics and the ET questions of concern. This was to be an information gathering process, intended to yield data from which the ARI and Contractor personnel might learn more about the ET questions and their potential answers.

Although the review could not be comprehensive of Army systems, it was desirable to be as complete as possible (within resources) with respect to any given system reviewed. Also, it was desired that the range of information collected be as broad as possible. Thus, a general approach was designed to attempt to gather as much information as readily available about a limited number of Army systems; spanning a range of system types, branches, personnel task variations and stages of development. The resulting review has accomplished this goal to a large degree.

METHOD

This section presents the procedures followed in the review of Army systems. It describes selection of the systems for review, preparation of the interview guide for data collection, collection of data on-site and the data analyses.

System Selection for Review

The systems were selected through three steps: 1) a quasi-inventory of all Army systems to determine likely candidates for review; 2) detailed consideration of the likely candidates and recommendation of the "best" systems for review to ARI and ASA; and, 3) final selection of the eight systems.

Quasi-inventory of Army systems

This inventory examined the range of current and developing Army systems and, therefore, the variety of tasks and training requirements represented. The intent was to insure that the review would include coverage of:

1) several branches of the Army service;

2) combat and combat support systems;

3) fielded and developmental systems;

4) systems that represented significant numbers of personnel and/or significant task requirements; and,

5) systems with and without ET in place or under consideration (especially ET components in place for some time).

The following criteria were used to reduce the potential systems to a manageable number:

1) Systems redundant to those systems selected were excluded. (e.g. - M9 Combat Engineering Vehicle was not selected because the M1 Abrams Main Battle Tank was a representative of its class of vehicle).

2) Combat service support systems were excluded due to their vast numbers.

2) Individual weapons were not considered as systems.

A comprehensive list of Army systems, both developing and fielded, was needed as the basis for the inventory. The Army Material Command (AMC) was the first source of information on both types of systems. AMC's Tri-Service Industry Information Center provided the 1985 listing of the Program, Project and Product Managers for AMC and TRADOC with addresses and phone numbers. The Army Research, Development and Acquisition (Army RD&A) and ARMY (October 1984 - the 1984-1985 "Green Book") magazines were also used for initial information collection. These sources allowed generation of the required list of systems which were fielded, in development or undergoing product improvement.

Jane's encyclopedic references were then used as the major source of information on the general characteristics of the identified systems (Jane's Publishing Corporation, 1983a, 1983b, 1983c, 1983d, 1983e, 1984). The Jane's information was used with other available data to briefly describe each system. The descriptions were then reviewed by all HSI project staffers and a consensus conclusion was reached about the potential of each system to provide information related to the definition and development of ET. This led to identifying 59 Army systems as the most likely candidates for detailed review, which still had to be reduced to fit the resource constraints of the project.

Recommendation of Systems for Review

The 59 candidate Army systems were then further evaluated to identify a subset that would provide the most information within the resources available. Using 5-point Likert scales, each system was evaluated on each of 12 attributes; consisting of the nine "Factors of Overall System ET Decisions" defined by Purifoy, Chenzoff, Harris, Roth & Strasel (1985, Appendix D) and three additional items. The nine decision factors were:

Q. 1: Will the system incorporate a well-defined, consistently used User-System Interface (USI) which provides for comprehensive information display and system control?

Q. 2: Will more than trivial additional displays and controls be required to implement ET?

Q. 3: Is there a reasonable probability that the prime system will be available for training utilization, given other system demands?

Q. 4: Will training utilization of the prime system (via ET) result in penalties to the Reliability, Availability, or Maintainability (RAM) characteristics of the prime system?

Q. 5: Is it likely that the conversion from training utilization (i.e., ET Mode) of the system to operational configuration will be time consuming, require significant effort or result in problems with system operability after the conversion?

Q. 6: Is the computational capability of the prime system sufficient, or inherently expandable, to accommodate ET implementation requirements, or can interface for strap-on computational capability be provided?

Q. 7: Will the prime system be subject to frequent or radical changes which could require major changes in the training provided by ET?

Q. 8: Will ET meet training needs more cost effectively than other possible training approaches?

Q. 9: Are there likely to be significant institutional problems with the introduction of ET in environments which previously have not had access to interactive training?

Our rationale for the use of these factors was simply that they appeared

face valid with respect to our concern about identifying useful information about ET in Army systems.

The three additional items deemed important to this evaluation were:

1) Need for team training

2) Need to simulate battle conditions in training

3) Number of personnel needing training

Our rationale for each of these three items was essentially identical: each was believed to be an important characteristic (but not the only important one) of systems that should be considered for the intensive review: team skill requirements means that the training requirement may be more complex than otherwise; the need to simulate battle conditions in order to accomplish effective training makes the training requirement more stringent, probably more expensive to meet and certainly more demanding of the instructor and the instructional program; and, the number of personnel requiring training is meaningful in two ways - for many personnel to be trained, the impact of the training program is greater and more cost-effective training will result in even greater savings by multiplication -- conversely, for a smaller number of personnel to be trained, it may be that an efficient and standardized training program in units is the only way to insure trained personnel on site due to personnel pipeline supply and routing problems.

HSI staff members rated each system on each of the 12 attributes. Our ratings on all items were based on the limited information available at that point, and so were gross indicators at best. These ratings were used to roughly order the 59 systems. No single factor or pair of factors was used to eliminate systems from consideration, rather these factors were used as a categorization device: to develop a better basis for recommendations of the "best" systems to ARI.

Ratings were then summed across attributes and raters for each system. This grand sum was used to rank the systems and they were then grouped by type of system (e.g. - Tank, Helicopter, etc.). Systems were selected from these groups for recommendation to ARI on the basis of rankings. Most frequently, the highest ranked system of a type was recommended for intensive study. However, because of the gross quality of the factor ratings, other considerations entered the decisions; these included the need to cover both fielded and developing systems and that some systems were to be examined in a related study (the ET Tri-Service Review, by Applied Science Associates, Inc.). The grossness of the indicators also suggested that more rather than fewer systems should be recommended. Therefore, this step resulted in 18 of the 59 systems being recommended for review. The recommended systems are listed in Table 1.

The number of systems that could be reviewed was limited by time and resource constraints. The number had been agreed with ARI to be from 8 to 10 and a priority scheme was necessary to assist the final system selection. A priority rating of one or two was developed, with priority one given to those systems felt likely to contribute the most to the project purposes. The priority ratings are shown in Table 1. Six individual systems among the 18 recommended were given a first priority because of unique characteristics

Table 1.

Systems Recommended to ARI for Final Selection for Review.

System Type	Rating	Pri	System Name - Designation
Air Defense Commo System	98	1	Short Range AD Command & Control ($SHORAD\ C^2$)
Anti-Aircraft Missile Sys	99	2	PATRIOT Surface-to-Air Missile System
Artillery Commo System	96	1	Advanced Tactical Data System (AFATDS)
Artillery Commo System	96	1	Tactical Fire Direction System (TACFIRE)
Artillery Missile	95	2	Pershing II Battlefield Support Missile
Artillery Rocket System	85	2	Multiple Launch Rocket System (MLRS)
Communication System	101	1	PLRS/JTIDS Hybrid
Intell/Elect. Warfare Sys	88	1	All Source Analysis System
Helicopter:	83	1	Light Helicopter Family (LHX)
or:	80	1	AH-64A Apache AAH
or:	82	1	AH-1S Cobra AAH
Howitzer	91	1	Howitzer Improvement Program (HIP)
Remotely Piloted Vehicle	80	2	Aquila (YMQM-105) Mini-RPV
Tank	90	1	M1 Abrams Main Battle Tank
or: Personnel Carrier	88	1	M2/3 Bradley Infantry Fighting Vehicle
Tank:	88	1	High Survivability Test Vehicle
or:	80	1	Rapid Deployment Force Light Tank
Weapon Location System	98	2	Weapon Locating System (Firefinder)

(e.g. - ASAS), perceived importance for lessons learned (e.g.- TACFIRE), or their complexity from a training standpoint ($SHORAD\ C^2$). Seven other systems were also rated priority one, but were grouped into three categories with the recommendation that only one of each category should be reviewed. The other five systems were rated as second priority: as less likely to contribute to the overall project.

Final Systems Selected for Review

The eighteen recommended systems were forwarded to ET researchers at ARI and ASA with the priority assignments. Discussions were conducted between ARI, ASA, and HSI on the merits, availability, criticality and potential

contributions of each system. ARI then indicated their final selections for the systems to be reviewed. These systems are described in Table 2.

Table 2.

Systems Selected for Review

System:	Type:	Branch:	Development Stage:
AH-64A Apache	Advanced Attack Helicopter	Aviation	FUE 1985
M2/3 Bradley	Infantry Fighting Vehicle	Infantry	FUE 1983
Patriot	Surface-to-Air Missile	Air Defense	FUE 1984-5
TACFIRE	Tactical Fire Control System	Field Artillery	FUE c. 1980
AFATDS	Advanced Tactical Data System	Field Artillery	Early: FUE 1990;IOC 1991
Aquila	Remotely Piloted Vehicle (RPV)	Field Artillery	Late: DT/OT II - 85
ASAS	All Source Analysis System	Intelligence	Early: ROC, MENS - 1981
HIP	Howitzer Improvement Program	Field Artillery	Early: MENS 1980;FUE 1988

Data Collection

It was initially felt that the data required to support the two related systems' review questions were highly similar and at least partially identical. While this was eventually true, the extent of identity was less than had been anticipated. This resulted in part from the difference in unit of analysis: The Tri-service ET review surveyed "ET systems" (not "systems with ET"); this review was of Army "systems", with or without ET, but with emphasis on the existing/proposed training system.

However, the initial definition of data requirements and development of data collection instruments were done jointly by HSI and ASA. When actual data collection was being planned, both ASA and HSI staff recognized that some idiosyncratic data subsets were required. This resulted in two separate interview guides which share the same biases and have many common elements - particularly in the area of training and the system development processes relating to training and to ET.

Data Collection Guide

The joint efforts of ASA and HSI staff produced a large pool of data types about systems characteristics and training systems. HSI used this data pool in development of the Army systems' review guide. The usable item-types were adapted for the specific needs of this effort. This included modification of some items and inclusion of others to better cover the important job-site testing, which has been recognized as a critical tool for both measurement and training.

Topics Covered in the Interview Guide: The interview guide was designed to collect data about all salient characteristics of each system to be reviewed. Based on our knowledge of the eight Army systems, and our prior experience with training systems and training developments, the following topical areas were defined as most likely to produce meaningful data about Army systems and their training needs and developments:

Weapon System Characteristics

Mission

History of System Acquisition

Personnel and Key Job Tasks

System Displays, Indicators and Controls

Computer Capabilities

Equipment Simulation of Key Combat Tasks

Provision of Accurate Feedback on Performance

Life cycle characteristics of Institutional and Unit Training

Existing/Proposed Institutional Training

Existing/Proposed Unit Training

Unit Training Costs

Availability for Training

Adequacy of Training System

Impediments to Training

The Structured Interview Guide: An interview guide was structured to obtain data in each of the areas listed above. Originally, the guide was to be designed for alternate use as a mail-back questionnaire. However, the range and extent of questions developed for each area precluded this use. The number of questions and the variations required for different system stages or training system characteristics dictated use of the guide only by staff members who understood what was truly wanted (everything about the system!). The derived interview guide is included as Appendix I to this report. It will be

noted that the 12 page version presented is single spaced - one with room to write on exceeded 20 pages.

Data Collection on Site

After system selection, it was possible to begin scheduling site visits and make telephone contacts with appropriate systems personnel. Dr. S. L. Burroughs (the ARI Contracting Officer's Technical Representative Alternate) made initial contacts with the appropriate Program Managers and proponent Schools to establish authority and credibility. These were followed up by HSI staff members to arrange specific visits or to request provision of specific system information by phone or mail.

On-site visits were extremely productive. Usually, the sessions with TRADOC Systems Managers (TSMs), training developers and systems trainers were the most productive. However, all sessions were useful and informative. In a few instances, relevant portions of the interview guide were used as a questionnaire and completed by training developers, unit training personnel, evaluators or other personnel. However, for the most part, the guide was used to structure discussion and the actual information was recorded by the interviewer. In the usual case the guide served mainly to assure that all available pertinent information was obtained. Dr. S. L. Burroughs participated in review visits to Fort Benning (Infantry), Fort Rucker (Aviation), Fort Bliss (Air Defense Artillery) and Fort Huachuca (Intelligence). Her assistance was invaluable, as both ARI representative and data collector.

In addition to the interview data, system design documents and training documents were obtained from appropriate parties. Many of these were obtained from the U.S. Army Infantry School Library. Some were obtained through phone contacts with the various system Program Managers and TRADOC System Managers. However, most frequently, such documents were obtained directly from training developers, combat developers, instruction managers or other personnel during visits to the Schools and system management offices. These site visits also typically provided important hands-on experience with the operational equipment, training devices, and/or embedded training devices for those systems where such items existed. This experience of observing task performance, and in some instances actually performing the tasks for the fielded systems, provided a level of understanding that could not have been obtained from literature or interviews. These tasks, particularly those that are highly perishable, are the primary targets of ET (Purifoy, et al, 1985).

Data Analysis and Reporting

When only a few people hold all of the relevant information about a system or the effectiveness of an embedded training system or its cost, there is no possibility of obtaining a random sample or of applying inferential statistical techniques. Fortunately, large agreement usually existed between the responses of different interviewees with knowledge of the systems and their characteristics. Similarly, recent documents provided data that were usually consonant with data from these interviews. Occasionally, system parameters were described in contradictory terms (once even in the same document) and follow-up phone conversations were required to identify the correct information.

In some few instances information was obtained from a single individual and it was impossible to verify the data from interviews with other experts or data from documents. When such idiosyncratic data are included in this report (as in the case of the effective unit ET reported for fielded Patriot), this is pointed out and attention is called to the potential problems of such data.

System Report Preparation

The initial requirement of data analysis and reporting was to assimilate the large amount of oral and written information received for each of the eight systems. The second task was to translate the assimilated data into a specific system report. These were accomplished by assiduous and continuous effort by a single staff member working separately on one (and only one) of the system reports at any given time. Once a draft version was available, another staff member (who had also reviewed that system) reviewed, commented and argued with the original author about the report. This continued until both staffers were satisfied that the report was as complete and accurate as our accessible data.

This process was repeated eight times and the individual system reports were completed. The first draft of each system report was submitted to the proponent parties for review and correction to assure the final version was correct. The revised reports are presented as Appendices A through H.

Cross-System Analysis

Following completion of the individual system reports, staff members concentrated on summarizing what had been learned and what this might mean for the ET questions at hand. This required detailed examination of the data summarized in each system report and review of these findings in relation to ET and the Army systems development process. The remainder of this report presents the product of this analysis.

FINDINGS AND DISCUSSION

This section briefly summarizes information from the eight separate system reports (Appendices A through H) and relates it to the total ET research program. The discussion concentrates on the diversities and similarities observed among the systems, with emphasis on the training and training systems. It also points out some highlights observed in the study which may directly relate to ARI's planning for further work in this area.

One highlight is most obvious now, but was not predicted. The selection process was designed to capture a variety of systems - combat and combat support, fielded and developing, etc.; but it was not intended to concentrate on systems with an ET component. Patriot and TACFIRE were included because of their status as major systems and for lessons learned. These were the only two systems known to have an ET component. However, six (6) of the eight systems studied were found to have (or have planned for development) an ET component to the training system.

Only the Apache AH-64 Helicopter and the Bradley Infantry Fighting Vehicle (M2) do not have ET components, existing or planned. This might even be argued for the Bradley, since several of the strap-on training devices used in gunnery training come very close to being ET (e.g. - MILES [the Multiple Integrated Laser Engagement System], the SAAB BT41 [a MILES-like device], etc.). All four of the developing systems studied (AFATDS, Aquila, ASAS and HIP) were found to be planning or already implementing ET components. Similarly, all four showed evidence of relatively early consideration of the ET aspect of training systems and of positive action by developers and users for its development.

Perhaps the point for ARI consideration is that ET is being considered, decisions are being made in favor of ET, and developers and contractors are charging ahead - whether they should and whether they know how to do it are not answerable. Perhaps the future emphasis might fruitfully shift somewhat away from the-whether-to-do it (and how, in terms of the LCSMM) and more toward the still critical questions of: what makes an effective and cost effective ET component; and how should it be developed and implemented within the Army's framework for training and evaluation. These and other questions are badly in need of answers. However, they are not the primary subject of this report.

Characteristics of Systems

As a first step in summarizing the systems' data obtained, Table 3 presents a partial summary of the data for each system. This briefly describes: each system and its mission; its acquisition stages related to ET; the personnel and major task types involved; system displays and controls; the system's computer, simulation and feedback potential; and, the training system. More details on all characteristics are included in the individual reports.

Systems and Missions

As shown in Table 3, the eight systems vary a great deal in type, function and mission. The two similar systems, TACFIRE and AFATDS, are really just two generations of the same system, designed to accomplish the same functions and mission: provision of fire control to a broad range of Field Artillery units, and with improvements, to individual guns. Both systems will interface with a

Table 3

Partial Summary of Characteristics of Eight Army Systems

Data Areas	Apache	Bradley	Patriot	TACFIRE	AFATDS	Aquila	ASAS	HIP
System, Mission	Advanced Attack Helicopter - Heavily armed attack ship. Arms include 30 mm gun Hellfire rockets. Pilot and copilot/ gunner provided with acquisition and engagement, and navigation capabilities for night operations. Replaces Cobra.	Infantry Fighting Vehicle:Squad Carrier, Wpns Plat. - Armored track veh. to serve Inf Sqd wpns and transpt. Two-man turret has 25 mm chain gun, TOW. Mobility, survivability, firepower gains over M113.	Surface to Air Missile System - Bn Info & Coord Central, Fire control sections (3-6 Bn), Comm relay, Launcher (8/Btry). All-weather ADA capability and major asset protection.	FA Tactical Fire Direction System - TACFIRE computer, mult. remote I/O devices/stations: Corps, Div, Bde, Bn & Co (FIST). 3 component grps; computer; displs; commo. TACFIRE interfaces, provides fire control to guns. Interfaces w/ mult. FA systems.	Advanced FA Tact Fire Direct. Syst. (Improved TACFIRE) Mult linked microprocessors serve FA C&C functions. Elements at Corps, Div, Bde, and Bn: I/O and gun con to mult. devices at unit level; provides FDC to individual gun.	Remotely Piloted Surveillance Veh. Unpiloted aircrft: TV, Laser desig/ Rng Findr (FLIR soon). Grnd Contr Stat w/ Cmdr, Ops. Remote term, ant. and electronics. Launch and catch truck mounted vehs. Target acquisition, designation and recconnaissance.	Tactical MI ADP System - Devel'g ADP sys. to support MI analysts at Bde thru EAC. I/O to all sources: SIGINT, HUMINT, IMINT, CCS2, oth Svcs, JSTAR, Nat'l Agencies. Produces Int repts for G2, G3, Cmdrs at all levels.	Automated Self-propelled Howitzer M109E5. Armored, tracked, crew of 5 155 mm cannon. automated FC w/ inertial ref; data, voice commo allows missions by gun or Btry. Tactical fire control provided thru BCS by TACFIRE or AFATDS.
Acquisition and ET	Apache is being fielded. ROC was c. 1963; AH-64 selected 1976. No ET in ROC or MENS.	BIFV concept initiated 1966. MICV modified to BIFV, 1976. IOC, FUE 1983. TDs 1985. No ET considered.	Patriot conceived 1970. First units deployed 1984. ET considered early and implemented at TPT with the fielded systems.	Initiated 1966. 1975 LP begun, DT/OT II 1977. FUE 1980. Prod. stopped because of AFATDS. ET dev by ARI, USAFAS, but unsuccessful.	AFATDS is in early development. Initial elements in procurement; P^{3}I program will continue. FUE 1990; IOC 1991. ET is included in reqs. *documents for syst.*	ROC mid-70s. FSED start 1979. First flight 1982. DT/OT II 1985. Procurement prob. delayed. ET has been developed and works in test for training *test players.*	ASAS is an updated version of *JTFTB (BETA) and TCAC,* meets additional ADP need for MI. Acquisition started in 1979 w/o ROC. MENS apprvd 1981. ET is planned in ROC, MENS, O&O plan.	HIP MENS 1980 from MAA deficiencies. *HIP is follow-on* to extended life program (HELP). HIP is in procurement. Production anticipated 1986; *fielding* 1988. A major ET effort is programmed.
Personnel and Tasks	Pilot and copilot/ *gunner operate* Apache. Key tasks are flying, navigation, target engagement with wpns systems. 10 maint. MOSs are required for unit and intermediate level maintenance.	Commander/Sqd Ldr, *gunner, driver are* the key personnel for BIFV system. Tasks inclu: tactical employment; target acqn., I.D. and engagement w/ 25 mm, Coax, TOW; conduct of combat.	AD Officer and Op/ *Maint EM are key* crew in ECS. Crew members setup and operate launchers, antennas, etc.. Tasks include: C&C of ECS and BCC; Ops of ECS, BCC; organizational maintenance.	Ops and maint need 4 MOSs: 13C,E,F, opns and 34Y maint. 13C10 soldiers are not trained to operate TACFIRE, only set up. Opns require 13C20-40 personnel. Tasks include computer and other equipment setup, operations, organizational maintenance.	AFATDS personnel *requirements and* tasks will be similar to those of TACFIRE. The same opns and maint. MOSs are defined at this time.	Main personnel for *Aquila are Mis*sion Comdr, Air vehicle Operator, Payload Operator Mission planning and execution are their responsibility. Other important tasks: launch and catch of the Aquila and maintenance. MOSs are being created *to meet new needs.*	ASAS personnel *include officers,* (MOSs 35A-G), WOs (MOSs 962,4;982, 3,8) and EM (MOSs 96B,C,D,G,J). All perform analysis; some will do C&C. Only data handling aspects of MI are dealt with by ASAS; analysis is *aided, not done,* by the system.	The HARDMAN study *recommended the MOS* 13BXX for HIP crew. These personnel to *serve as Gun Chief,* gunner, assistant gunner, driver/gunner and cannoneer/ ammo handler.

Table 3

Partial Summary of Characteristics of Eight Army Systems (Continued)

Data Areas	Apache	Bradley	Patriot	TACFIRE	AFATDS	Aquila	ASAS	HIP
Displays, Controls	Heads up displays for P and CP/G allow good control; Helmet displays, (HDUs) give one-eye views of both world and panels. Controls and indicators SOA std. Head sensor systs. provide look-and-shoot capability.	*Main display*: ISU for Tgt Acqn and engagement. Oths std indicators and lights. Controls mech., pwr-assist, and switches. *ISU* and Drvrs viewers give thermal tgt, *psn detection in* limited visibility.	*Main displays are* PPI CRTs: symbology and tracks; Alpha msgs also. *Ops* use keyboards, pushbuttons and switches *to input.* PPIs present asset, frndly, host. flts, locations, dir, & *info on ECM cap.*	TACFIRE displays mainly Alpha msgs on CRTs - *in and out. Map plot bd.* and rnd CRT used for battlefield *info. Prime input* by keyboard and pushbuttons. Cmptr controls are std.	Sim. to TAFIRE, updated: int terms. *and adv. displays. Fire Support Term* to be interactive w/ I/O display and keyboard. Large (1 m sq.) CRT for battlefield disp. where needed.	3 hi-res CRTs mon activity of RPV & grnd tgts, etc. Airborne video is displayed (sim to FOG-M) w/graphics overlays. Plot board. Syst I/O by keypad, joystick, pushbuttons, dials, indicators, etc. DMD input: TACFIRE; AFATDS.	Workstation has: color graphics CRT, Hi-res Alpha scrn, & prntr. 1 m sq. CRT at CEWI, etc. Little add'l info available on ASAS hardware.	FC Ops cons. has graphic disp. cap. for loc of Btry asssets on map. I/O likely to be keyboard, sws., oth disps. Inert. Ref and Az. Psn'g syst to be incld. Sftwr to be menu-driven w/ prmpts.
Computer Capability, Simulation, *Feedback*	Apache: 2 cmptrs: unk cap.; avail. Can sim most tasks *inflight - not tgt* acqn/desig'n - no Laser simulator. Fdbk extnl; intnl *fdbk poss., not in* current plans for Ops. Maint fdbk good with FD/LS.	No computer. Sim of major tasks is poss., fdbk is lim-*ited w/o extnl in-*put devices as MILES or tgts on ranges. FTX is the best simulation of Bradley tasks.	Cmptr has 256K wrds mem, mass storage, and reas. I/O. W/ *TPT*, syst provides sim of most ops tasks and provides some fdbk. Fdbk could be much improved by using more detailed meas. for perf. assessment.	Large, obsolete, computer; CAI, tapes simulate Ops, not much use. Need improved sftwr to incr. use & value of trng capabil avail.	Large cap. cmptr - 16-20 Mb RAM w/ bubble cass. I/O capabil. wd allow extensive trng devel. and applic. Wd also allow Sim of I/O and FDC Ops and detailed perf. assessment and feedback, if done.	Current cmptr is limited - des chng planned to upgrade to 512Kb and 1 Mb bubble cass. stor. Sim of Ops tasks poss. w/ strap-on TIU (ET device). TIU and syst disps also provide visual fdbk on perf. - *of Go-NoGo type.*	ASAS, mainly ADP system, has huge aggregate cmptr capc. System can be developed to provide full sim and feedback on all performance of Ops and analysts (*on* the system - not analysis w/o Exp. *Systs development*)	Unk, but SOW calls for 50% res RAM over opn'l reqs. Indef plans, but planned cmptr capc should support detailed, complete ET system to sim *all essential* tasks and give extensive fdbk.
Training: Institut'n Unit Costs	Apache trng for both Ops and Maint appears good at School. Unit trng may pose probs due to lack of abil to practice tgt engagement tasks. Trng devices are used in instit and soon in units. No ET, but desired. Little cost data.	Bradley trng in instit and unit could be improved. School trng concentrates on gunnery to exclusion of impt tactical, doctrinal trng. Trng devices becoming avail in school and units. Pseudo-ET w/MILES, SAAB BT41, etc. *Ammo costs only.*	Patriot has full complement of Inst trng courses for Ops and Maint. Unit trng, other than TPT and LAT (ET devices), is not well defined. First units in USAREUR 84-85. School doing "packet" trng for units. Inst trng devices *used, AET also.*	TACFIRE trng is mostly on AET with the ARI-developed CAI for Div., team tapes for Bn. Both are exported to units, but usage is reported low. TACFIRE trng is reportedly a) not done much; b) restricted by equipment lacks.	AFATDS planned to avoid trng probs experienced in TACFIRE. Details *not yet available,* but institutional trainer is in plan. Courses are listed at USAFAS. Unit trng is planned to rely heavily on the to-be-designed ET package.	Aquila training is fully planned, w/ both instit and unit approaches in progress. *Instit* trng is MOS specif and reqs c. 25 wks. Packet trng unit personnel takes seven weeks. The TIU (ET device) is to be an impt part of unit trng in *the field.* Little is yet known about trng costs or trng effectiveness.	ASAS is unique. It assists tasks already performed; already trained. *What's needed is* ADP equipment trng and that's what USAICS is going to incorporate into (or extend) the current trng courses. Two sim/ TDs are in devel *to assist eq trng.* Instit and unit *trng plans are yet* incomplete.	Few trng changes anticipated for instit courses. Will be 2 new TDs *PM-TRADE-defined.* PM-TRADE also defined 2 options for ET developments and system contractor is to deliver ET pkgs. *Other than minor* course changes, the TDs and the programmed ET, HIP *training will be* like M109 trng.

multiplicity of fire control and firing elements, from enemy locating systems, like Firefinder, to the firing battery or gun (as with HIP).

The other six systems are quite diverse. Three of them involve guided flight of a vehicle or missile, with one piloted locally (Apache helicopter) and two remotely (Aquila RPV and Patriot surface-to-air missile system). BIFV fights and supports a dismounted Infantry squad while moving rapidly on the ground. Apache and BIFV frequently bring their occupants into visual and machinegun contact with enemy forces. Aquila and Patriot work at relatively long range from the enemy while performing reconnaissance and surveillance (Aquila) or attempting to destroy enemy aircraft (Patriot). These last two, like the remaining systems, will operate from temporary stationary positions located behind the lines with operators located in truck-mounted vans or a tracked vehicle (HIP).

From these remote locations, the operators of the Patriot and HIP systems fire on the enemy and Aquila operators survey and laser-designate the enemy as depicted on CRTs. TACFIRE, AFATDS and ASAS operators deal with information about the enemy, but do not have the direct effects on enemy forces of the operators of the other systems.

Large differences exist in the missions of these eight systems and these are reflected in related pronounced differences in the operator tasks. BIFV personnel are largely concerned with traditional seek-and-kill actions, mainly against distant real-world visual images. Apache pilots and copilot-gunners survey both the real world and CRTs for targets and when they find them machine gun, rocket or laser-designate them. Aquila operators also survey the world but their world is strictly a CRT video depiction. Laser-designation by the Aquila Mission Payload Operator is comparable to that of the Apache copilot-gunner and both are assisted in this by automatic trackers that lock onto the target.

Patriot operators deal with many targets simultaneously with many missiles. This fighting is done in air-conditioned vans against symbols viewed on large CRTs. Advanced Field Artillery Tactical Data System (AFATDS) operators and Tactical Fire Control System (TACFIRE) operators are basically computer operators who specialize in handling alphanumeric message traffic in support of Field Artillery. Howitzer Improvement Program (HIP) operators will also handle alphanumeric message traffic but some of their inputs to the computer will also aim and fire the cannon of this developing automated howitzer system. Operators of the All Source Analysis System (ASAS) also deal with intelligence "messages" but these messages are about an enemy that is trying to prevent or falsify such messages. Their task includes much cognitive problem solving since the messages are like pieces of a jigsaw puzzle that must be correctly assembled.

Table 3 has summarized this information briefly and additional details for each system are contained in the Appendices. These describe system types, missions, and functions as well as the other characteristics separately for each of the eight Army systems reviewed.

System Development

Stage of development of the weapon system was well covered by our sample of systems. TACFIRE has been fielded for a period of about five years (first

unit equipped in 1980), Bradley was initially fielded in 1983, Patriot in 1984 and 1985 and Apache is gcing to units this summer (1985). On the developing side, ASAS, AFATDS and HIP are farthest from fielding with no prototype equipment. Aquila is much farther along in development and is currently undergoing both its Developmental Test and Operational Test II (summer 1985).

TACFIRE has been around much longer than the other systems; so long it is already considered obsolete and will be replaced with AFATDS starting in about 1990. However, some Field Artillery units are just obtaining TACFIRE equipment.

The length of the development cycle for major systems is illustrated by the dates for ROCs, MENs, and subsequent significant events in these systems' life cycle as shown in Table 3. As a good example, the Apache concept, the ROC, was prepared in 1963, the final configuration was selected in 1976 and the bird is being delivered in 1985. Similarly, the Bradley requirement was initiated in 1966 and the first units were delivered in 1983. More recently, the concept for ASAS was started c. 1977, initial procurement was authorized in 1979, but one still does not see the first piece of gear until 1986. And the objective system will not be fielded until the 1990s.

In Table 3 ET is tied to the acquisition cycle because of ARI's interest in inputting to decisions about training systems early in the life cycle. It can be seen that where ET is found (or, mostly, is being developed), the ET component of the system's training package was defined as an early requirement. However, it must be clearly stated that in no case was there found any solid analytic or empirical basis for ET being included in the system acquisition. Decisions were apparently largely based on anecdotal evidence, including observation and experience with other systems and training systems.

Other System Characteristics

Table 3 also summarizes the personnel and job requirements of operators of the systems. This was found to be closely tied to standard job classifications (MOSs) and represented little difference in task requirements from former systems. This is more true, obviously, for the Apache and the Bradley than for some of the other systems. Apache and Bradley personnel are truly "operators" of the system; they turn handles, push levers, move weapons platforms and squeeze triggers (most likely the future HIP personnel should be included in this group also, but we can not yet know). Personnel of the other systems tend to be monitors, input/output people, analysts, typists and button pushers. This conclusion may be stronger than warranted, but some data are there and one should note where the ET is being implemented: for those tasks which are less "operational" and more cognitive or knowledge-based. Details of these requirements are found in the appendices and the implications of systems' tasks for training with ET are discussed later.

Three other areas with implications for both training and embedded training are also summarized in Table 3. These are displays, controls and indicators; the computer capability and simulation area; and, the provision of feedback to operator performance which is inherent in the system. Again, it should be noted that the fighting systems have different kinds of displays: direct views (except for the CRT's re-creation of the direct views in the Apache) rather than symbology, alphanumerics or even video to represent the real world. They also have different controls as discussed above.

The differences in computer capability probably mostly reflect the differences in functional requirements of the different systems. However, the system's computer capacity greatly affects or enables: capability for simulation of operational (and maintenance) task requirements; and, the possibility for provision of adequate feedback on operator (or maintainer) performance. With the fighting systems, simulation inputs and feedback must both be received mainly through the direct viewing device(s) or the auditory pathway. When one has the luxury of being able to input to a CRT (or an electronic plotter or an alphanumeric readout), one could probably simulate "real world" inputs much more easily than creating a complex visual scene for the eyeballs to interpret. Similarly, the higher computer capacity should allow increased performance measurement and feedback; higher capacity provides increased accessibility to system and operator/maintainer performance measures and thus can facilitate the provision of adequate feedback on good and bad performance.

This raises the issue that should be clearly pointed out here: that of performance assessment and feedback to students and commanders. While several systems reviewed contained some evaluation capability, none has a full capability to do full task performance assessment. All systems do a partial job of evaluation and feedback (even the Bradley and the Apache let the pilot/commander know quickly when something is going wrong with the major system operation). Patriot includes an evaluation algorithm in its Troop Proficiency Trainer (TPT), an ET component, but assessment is poorly detailed and "good" feedback doesn't necessarily mean good performance. Systems which are planning to include an ET component should also be planning to include embedded performance assessment.

Existing/Proposed Training Systems

This section summarizes the training systems for the surveyed systems. It presents: descriptions of institutional and unit training, including training devices, simulators and embedded training, where applicable; brief notes on training costs; and, a summary of the types of training problems observed, reported or anticipated in these systems.

Institutional Training

All systems training developers either have developed or are planning full institutional training programs. These were found to be in correspondence with the Individual and Collective Training Plans (ICTPs) when they were available. The programs usually include detailed lists of specific courses to be administered, training equipment, devices and simulators to be used and POIs (Programs of Instruction) for course/training presentation.

Courses: All systems managers and training developers have defined full menus of courses which produce personnel with defined Military Occupational Specialties (MOS) or Additional Skill Indicators (ASI) that identify them as school-trained in the course. Aquila has created new MOSs (13TXX) to meet the special requirements of system operation, and Bradley has done the same (11MXX). Other systems have usually modified standard MOSs and standard training to meet modified requirements.

Where courses could be specifically identified, they are listed and/or described in the individual system reports. For most systems, course names,

durations, and POI outlines were available for examination. AFATDS even had a list of the courses that would be taught, but little else in the way of training developments.

Among the fielded systems, Apache school training is extensive and uses large, high fidelity, simulators at US Army Aviation Center and School (USAAVNCS); the training appears to be well done and is producing pilots judged fully capable of handling this difficult system. Pilots and Copilot/Gunners receive the same training - as both pilots and copilot/gunners. Possible changes have been discussed to train copilots only to operate the front seat and only to land the aircraft in an emergency. Bradley training is concentrated mainly on gunnery and places very little emphasis on the differences in tactics and system employment required with the Bradley as contrasted with the M113. Bradley training also uses training devices and simulators in all four courses.

Patriot also has a comprehensive program of both individual and collective training of operators and maintenance personnel. Currently, Patriot unit personnel are trained as a "packet" at Fort Bliss before deploying. This includes individual courses, collective training and unit training with the actual Patriot equipment (AET) and training on several devices also. The training situation for TACFIRE is less good. Although there are training courses these use mainly conventional instruction in conjunction with several sets of AET. No devices nor simulators are available or planned for TACFIRE. However, there are two ET capabilities which are used in institutional as well as unit training: the Planit-based CAI lessons developed by ARI and USAFAS; and, a set of team oriented tapes which provide training to battalion and division level TACFIRE personnel.

Among the developing systems, although all have training programs defined, only Aquila is actually doing training. ASAS, AFATDS, and HIP are still too early in development to be at this stage. All three systems have programmed training devices for initial training, however. These are discussed below.

Aquila has a fully planned training system, with both individual and collective training courses in progress. USAFAS is also doing packet training of Aquila crews with individual MOS training taking about 25 weeks and the collective (unit) training requiring seven weeks. Aquila is also developing a multi-station training device for institutional training. A separate unit, the Training Interface Unit (TIU), serves as a strap-on ET device to present (low fidelity) simulated video images to operators. This TIU is currently being used at USAFAS to train operators for Operational Test II of Aquila.

One possible use of ET would be to do more of the initial operator training in the units and thus to reduce institutional training. However, there were no such plans for any of these systems. Reduction of institutional training through the use of ET should be considered in trade-off studies of training costs in the future.

<u>Institutional Trainers and Simulators:</u> Apache has and BIFV will have large expensive training devices for institutional training. This is understandable for the helicopter system since aviation has a long history of using devices to avoid expensive flight training, but may be somewhat surprising for a ground vehicle. On the other hand, 25 mm training ammunition costs about $30 per round and the gun fires at 100 or 200 rounds per minute. Low cost

substitutes (laser, sub-caliber or other gunnery training devices) make a great deal of sense.

Among the systems studied in this review, training devices may play their most critical role for the Apache Helicopter System. The major Apache training devices are the Target acquisition/designation System Selected Task Trainer (TSTT), Cockpit Emergency/Weapons Procedure Trainer (CWPT), and Combat Mission Simulator (CMS). The Apache crew member is trained in basic and advanced systems procedures with the TSTT training device. The TSTT replicates the copilot/gunner's station of the Apache, including target acquisitions and weapon and navigation systems but excluding the Integrated Helmet and Display Sight Subsystem (IHADSS). The TSTT does not require a dedicated instructor. Training is based on menu-driven, fully-prompted scenarios. Training scenarios include basic and advanced switch manipulation (switchology), individual systems operation, and integrated systems training.

The CWPT provides training for Apache crew members in normal and emergency procedures. It replicates the crew stations of the Apache, to include all flight controls; target acquisition; and weapon, navigation, and communication systems, including IHADSS. Visual displays are provided for all sensors, except out-the-window, with vector graphics including terrain features, threat arrays, and weapon effects.

The CMS provides a training capability for flight and weapons delivery, normal and emergency procedures, and sensor system operating tasks required in the operational mission of the basic helicopter. The Apache CWPT and CMS devices currently are only available in the school environment but plans are to make them available for sustainment training in units in the U.S. and abroad. These training devices are the only way that Apache operators can train to designate targets with the laser, to fire Hellfire missiles and to perform emergency procedures: these cannot be trained in the operational aircraft because of the non-eye-safe laser.

A variety of training devices has been developed, proposed or planned for potential training of Bradley Infantry Fighting Vehicle (BIFV) gunnery tasks. The currently available training devices and aids for the BIFV fall into several categories derived from device characteristics. They include "add-on" interactive Laser systems, such as the Multiple Integrated Laser Engagement System MILES) and the SAAB BT41; strap-on gunnery training devices, such as the Bradley Gunnery and Missile Training System (BGMTS) and the Reavis/Brewster device which allows the use of either an M16 or the M55 Laser as a substitute for main gun firing; and simulators/procedures trainers, such as the sophisticated Conduct Of Fire Trainer (being developed in both Unit and Institutional models) and the videodisc-based interactive gunnery station (the VIGS - the BIFV version of the part-task tank gunnery trainer).

The Patriot system also has several highly sophisticated institutional training devices for both operator and maintenance training. The major institutional operator training device for Patriot is the Patriot Conduct of Fire Trainer (P-COFT) which is a multi-station trainer that simulates all displays and functions for Patriot operators. It can be configured to simulate either the ECS or the BCC station and will train personnel on both sets of tasks. There are seven P-COFTs in use in institutional instruction at the US Army Air Defense Artillery School. Each P-COFT can train eight students, either individually or collectively. The P-COFTs provide simulations/

stimulations of the Patriot system displays, controls, communications, and data processing systems.

Aquila will have a dual institutional/unit training device capability when its multi-station training device is developed for operator training. This device will use videodisc imagery under computer control to provide video that responds to operator inputs affecting the RPV flight and the sensor payload. HIP and ASAS also are developing or planning the development of multi-station institutional training devices, but these are not yet well defined.

TACFIRE uses only a few sets of operational equipment in institutional training. Training devices have not been developed despite an equipment shortage; this apparently reflects an attitude of waiting for AFATDS to solve both operational and training problems.

Unit Training

General: The unit training program throughout the Army is the responsibility and the prerogative of the Commander. The Commander, through his staff personnel and actual training personnel, defines, administers, evaluates and corrects the training program and its actual conduct. He does this based on: guidance from higher commanders; evaluation by external review parties (as in external ARTEPs [Army Training and Evaluation Program exercises] or a session at NTC [National Training Center]); internal evaluations (such as squad or platoon ARTEPs or SQTs [Skill Qualification Tests]); and, his own knowledge of his unit's tasks, standards for their performance and their current proficiency levels.

If this sounds like a tall order and a big responsibility, it is. External evaluation or control of the unit's performance (ARTEPs) is acceptable throughout the Army. External evaluation or control of the unit's training program is not only unacceptable, it is taboo. There are two main reasons why higher Commanders do not direct unit Commanders how to train their troops in the modern Army (and probably throughout history):

1) The authority of a Commander must never be abridged or usurped by a higher Commander (Relief from command is acceptable when necessary; usurpation is never acceptable); and,

2) Neither the higher Commander nor anyone else in the chain of command knows what precisely to tell that unit Commander about how to train.

It is difficult, near to impossible, to know which reason operates more strongly to produce the nearly impossible job of the Commander and his training staff.

Given that unit training for our systems will be operating under the above caveat (until someone determines what to tell the Commander), we can expect the systems' units to perform training much as it has been done in the past for systems similar to these eight. Unit training, then, will include: individual and crew drills in the garrison setting or in the motor pool; individual and crew drills in the LTA (local training areas) adjacent to garrison; practice on available ranges (as appropriate to the system); command post (CPX) and field (FTX) exercises at LTAs and MTAs (major training areas); annual to biennial

exercises at NTC; and, such other training as the Commander deems necessary, required and desirable.

Hopefully, given the system has an ET component, part or all of the individual and crew drills would be spent operating the equipment in the ET mode. This is a distinct advantage of ET for the Commander and his staff: ET can provide a structure and a "program within a program" for his training. This alone may be a sufficient incentive for the Commander and his staff to use, and insist on the use of, ET. This advantage to the Commander may become the strongest selling point for eventually incorporating ET into a large variety of systems. The current status and application of ET in unit training is addressed in a separate subsection below.

As indicated above, a number of the systems' training devices developed for institutional use (or modifications thereof) will be used in unit training as well. This includes the planned dual use of the Aquila institutional trainer being developed (and perhaps the TIU as well). Other systems which will use such devices in the field include Patriot, Apache, Bradley and, possibly eventually, HIP and ASAS.

Unit Training Devices: The training devices currently used or planned for use are discussed here by system. The fielded Apache system requires the use of training devices and simulators for much of its non-flight training. It has no ET component. There also is a long tradition of separate training devices to provide initial and sustainment training for pilots and copilots. The Apache Cockpit Emergency/Weapons Procedure Trainer (CWPT) and Combat Mission Simulator (CMS) devices currently are only available in the school environment but plans are to make them available for sustainment training in units in the U.S. and abroad. These training devices are the only way that Apache operators can train with the laser: to designate targets; to fire Hellfire missiles; and, to perform emergency procedures. These cannot be trained in the operational aircraft because of the non-eye-safe laser.

Unit training for BIFV is largely based on perseveration of former training practice. However, gunnery training and commander/gunner interaction training are to be provided by the FV-UCOFT (Fighting Vehicle - Unit Conduct of Fire Trainer) which are being issued, one per battalion, over the next several years (first fielded May 1985). A variety of other training devices (listed above under institutional training) are also available for unit training. Tactical training for Bradley operations continues to be provided primarily by CPX and FTX at LTA and MTAs.

There are plans to send two Patriot Conduct of Fire Trainers (P-COFTs) to Germany to provide Patriot operator sustainment training. However, the Troop Proficiency Trainer (TPT) appears to meet the same training requirements as the P-COFT, given the new capacity to convert P-COFT scenarios for use on the TPT.

Embedded Training in Units (Systems)

Of our eight systems, four are fielded to some extent and, of these, Patriot and TACFIRE have ET packages. Patriot's major ET component is the Troop Proficiency Trainer (TPT) which provides operator training on the operational equipment itself. It is an embedded unit trainer which requires only the calling up and running of computer programs that exist within the Patriot system computer. The TPT can be activated or deactivated in one

minute. Currently seventeen different scenarios exist which provide comprehensive operator training including full simulation of normal Battalion air defense missions. It is now possible to produce scenarios on the P-COFT and translate them for use on the TPT. These extra scenarios will increase the training potential of this embedded trainer.

Another ET component for Patriot will be fielded in the spring of 1986. It is the Live Air Trainer (LAT) and uses the Patriot radar set to provide targets for operator training. The launcher is disabled and the LAT simulates launch and flight of missiles when the aircraft that appear in range are fired on. Such "targets of opportunity" will differ greatly in number and behavior from the simulated enemy aircraft appearing during TPT use (and from real attacking aircraft). For this reason, day-to-day training with the LAT would probably have only moderate value, especially if novel or otherwise challenging scenarios were available for the TPT. The LAT will come into its own during major field training exercises (FTXs) when NATO air forces fly missions that simulate attacking and defending aircraft. Although the fielded Patriot units have been in Germany only a short time, it was reported that the first unit deployed is using the TPT for much of the unit training of operators.

Embedded training for the fielded TACFIRE System consists of computer assisted instruction (CAI) lessons and team training tapes. The CAI lessons were developed with PLANIT language for institutional individualized instruction. They were subsequently incorporated into the exportable training material supplied for unit training. These are structured lessons, aimed primarily at the novice TACFIRE student. These CAI lessons do provide some feedback and recordkeeping capability but are limited to TACFIRE operations specific to the Division Artillery computer. No CAI lessons are presently being exported to Field Artillery Battalions for individual instruction.

The TACFIRE team training tapes which are provided to units at both battalion and division levels, provide a collective training capability. This training capability is limited primarily due to an inability to collectively assemble all team members so team training can be conducted. The team training tapes consist of message formats that must be correctly completed and transmitted between computer operator and Tactical Operations Center Variable Format Message Entry Device (VFMED) operators. Operators must still utilize their manuals to determine correct entries for each format utilized in the scenario. No individual feedback is provided and only general feedback on team operations. No record-keeping capability exists.

Due to its outmoded and unfriendly computer, the TACFIRE system has an extremely difficult and highly perishable set of operator tasks that are not being kept to high levels by many of the units. The team-training tapes and PLANIT individual operator ET materials receive almost no use. The same, however, is true of other exportable training developed for TACFIRE operators. TRASANA reports that other forms of TACFIRE unit training such as FTXs are not occurring or are only occurring infrequently (TRASANA, 1985).

The four developing systems (ASAS, HIP, AFATDS, and Aquila) all have requirements for ET packages to provide sustainment training. Aquila has already developed an ET component for unit training known as the Training Interface Unit (TIU). This strap-on embedded trainer is already proving its value even though Aquila is only at Operational Test II. The TIU uses computer generated imagery (CGI) to simulate terrain and targets for operator displays.

This CGI does not closely simulate the video provided by the Aquila sensor package but it provides Aquila operators with the experience of piloting the RPV and aiming its sensor payload.

Another Aquila ET component being considered for development is the Surrogate Aquila Training System or SATS. This will consist of the Aquila mission payload strapped on a helicopter or other manned military aircraft. This will permit the simulation of Aquila missions without the use of an actual air vehicle. This substitution may be required because of a lack of suitable ranges, safety restrictions and airspace limitations or constraints in the U.S. and overseas areas. The strap-on payload would be used in major military exercises for the training of target identification and designation for the Aquila battery and operational sections including commanders and staffs. In particular, the video provided would be useful for training Mission Payload Operators and Mission Commanders in target identification and designation. The helicopter would fly a preset route as the Aquila itself does but it also would respond to commands for flight changes from the Air Vehicle Operator, maintaining Aquila speed and other flight parameters.

Embedded training is included in specifications for AFATDS development. However, specific features of this ET component have not been described. Computer capacity, peripheral devices and displays proposed for AFATDS would appear to be adequate to support the most sophisticated ET component imaginable. For example, there is discussion of the inclusion of as much as 16 to 20 megabytes of RAM. Peripheral input devices may include bubble memory cassettes (presumably with capacities also in the multi-megabyte range) which could be used to input ET courseware to the system. Large CRT displays are planned which would eliminate need for slow and inflexible plotters and this dynamic display capability should easily allow training of operator skills and knowledges.

This huge CPU capacity, memory capacity and data/program input capacity projected for AFATDS would easily allow even non-system skills and knowledges to be trained. With proper equipment design, "networking" (distributed processing) could occur and instruction could be sent to terminals located away from the AFATDS vehicle to assist with Skills Qualification Test (SQT) qualification, sustainment training and cross-training of large numbers of AFATDS personnel and other nearby Field Artillery (or other) personnel. This networking suggestion emanates from personnel at the Multiple Launch Rocket System (MLRS) training branch: the MLRS ET was insufficient to provide training to all personnel needing it. Additional terminals affixed to the large AFATDS computer system could possibly solve this problem which might exist for AFATDS and HIP as well as MLRS.

Embedded training is a requirement for the HIP system and a PM-TRADE training device study (including ET) is a reference and standard for the contractor. These factors argue for development of an effective ET package for HIP. HIP operators should benefit from software developments that are modeled, in part, after those used with the somewhat comparable Multiple Launch Rocket System (MLRS). The MLRS system can prompt even inexperienced personnel to successfully program a fire-control mission within a few minutes.

For the ASAS System, ET was established early in the procurement process, and is a required deliverable in the procurement contract. The contractor (Jet Propulsion Laboratory) has conducted a study to determine ET requirements and

costs. Four progressive level training programs, with increasing attendant costs, were recommended. No decisions concerning this study have been made.

The ASAS ET component is an extensive requirement in that it should not only provide detailed operator equipment training but also assist the analysts in sustainment of their cognitive task requirements. Discrimination, decision-making and integrated performance skills are required to be developed and maintained. Similarly, these tasks involve knowledge of concepts, rules and principles for all system operator/analysts and managers. This will require a lengthy development process. Unfortunately, this time period may not be available for ASAS due to current resource constraints.

Additional expenditure of effort in the design of ET packages for all four of these developing systems (including Aquila, given its lack of performance measurement) could provide large payoffs in effective unit training. A specific additional effort to achieve this for HIP has been proposed. A similar effort could enhance the ET for AFATDS. Unfortunately, there do not currently appear to be adequate funds or consideration being given to maximize this AFATDS ET opportunity.

Training Costs

Data on training costs were very meager for all systems. What little data were available for any system are reported in the individual system reports (Appendices). There is no attempt to summarize them here.

Training Problems

Of the four fielded systems, TACFIRE probably has the most problems for training of its operators. These problems are directly related to the obsolete and "user-unfriendly" TACFIRE computer with its numerous message formats, multiple switches/pushbuttons and lack of software prompting. There is a shortage of equipment for institutional training and no training devices. Further, the individual ET developed to provide training in the field is not available for Battalion TACFIRE personnel. On top of that, most commanders do not recognize the large need for sustainment training in order to maintain the highly perishable skill of operating this complex computer hardware and software. Typically, poor performance in FTXs or National Training Center exercises is blamed on the hardware. But there are a few unit Commanders who make the intense sustainment training commitment required to successfully operate the TACFIRE computer and system and their units do not have "equipment" problems.

AFATDS is being designed to reduce many of TACFIRE's operator training problems. The AFATDS computer and software will be much more "user-friendly" with many software prompts to aid in the generation of messages. Undoubtedly, perishable skills will still exist despite these efforts to design them away. Sustainment training of these skills with ET devices and other training will still be needed despite the fact that training problems should be less than for TACFIRE.

Patriot operator training is reported to be occurring frequently and effectively. However, the system has been available for unit training for only five months (summer of 1985) and this report comes from a single evaluator from the 32nd AADCOM in Germany who was TDY to Fort Bliss during our visit.

A potential problem in unit training for Patriot operators is that there may not be adequate challenge for operator ET with the Troop Proficiency Trainer due to a lack of novel training scenarios. Additional scenarios are to be developed to maintain interest in training and to keep it challenging. These new scenarios also need to represent the actual assets and geography that these fielded units will be defending. The Live Air Trainer will allow simulated engagements of actual air traffic and provide additional novel unit training when it becomes available in the Spring of 1986. This will be especially beneficial during exercises where the Air Force pretends to be attacking aircraft.

Some of the problems of non-novel scenarios might be eliminated just by improving the performance assessment capabilities of the TPT and of other ET components. Scoring how quickly responses are made as well as their rightness/wrongness could add much interest to these engagement simulations.

Potential training problems with Apache pilots and copilot/gunners will exist if the Apache training devices currently available in the school environment are not made available for sustainment training in units in the U.S. and abroad. As mentioned earlier, these training devices are required to train laser-designation, firing Hellfire missiles and emergency procedures.

ASAS analysis functions require a high degree of cognitive processing which requires frequent practice to sustain. The highly complex cognitive tasks required of analysts to perform their duties can not be maintained at a high performance level if they are limited to performing those cognitive tasks two to four times a year, during field exercises. Research has clearly indicated that constant practice is required to sustain proficiency in cognitive skill tasks. Without an efficient ET program in ASAS to sustain operator/analyst performance, system capabilities will be degraded until such personnel become refamiliarized with system tasks. Although ET is going to be included in the final ASAS system to be fielded after 1990, it may not be available for the baseline system. Without it, operators will not receive the training needed to maintain the complex ASAS operator skills.

BIFV training has more than its share of problems. With respect to current training in units, a number of problem areas were observed and reported by unit personnel. These include serious concerns about use of the integrated sight unit (ISU), especially the thermal viewer; night gunnery training; night training in general; and, target acquisition, recognition and engagement. Major concerns are also reported by units about the training of both Master Gunners and BIFV Officers. Similarly, the units report concerns about the total gunnery program, its progression and the various qualification requirements for different levels. There are also reports of concern about requirements for conduct of preliminary training, dry-fire gunnery and sub-caliber gunnery training.

Despite the fact that Aquila is still a developing system, the Aquila Training Interface Unit (TIU) ET component has already been successfully used for training Operational Test II personnel and training personnel at the U.S. Army Field Artillery School are delighted with the TIU. The device allows operator trainees to fly the aircraft, operate its television camera and locate/track targets through simulation without actually launching an air vehicle. However, its success as a training device may be short-lived, if the five scenarios available for the TIU quickly lose their training value as a

result of becoming overly familiar to operators (as has been found to be the case for the Patriot ET scenarios). Given the recognized need for additional Patriot ET scenarios, it is probable that more Aquila ET scenarios will be needed as well.

An even more serious problem than non-novel scenarios may be related to the question of whether the TIU is training these operators to fly well, operate the television camera well or to do a good job locating and tracking targets. The TIU is lacking in that it does not provide an operator evaluation capability. This lack of testing/feedback/evaluation in the Aquila TIU must reduce its potential capacity to train despite its superb capability for simulating air vehicle flight and sensor movement. Admittedly, RPV tactics and doctrine are at such an early stage of development that it may not be known yet exactly what constitutes good performance. When these questions are settled, the TIU or any successor ET component needs the capability to test operators as well as to train them.

Unfortunately, all ET components we studied share this weakness of poor assessment and evaluation of performance. Even when such capacity presumably exists, it is inadequate. For example, Patriot evaluators who used the Troop Proficiency Trainer to evaluate Patriot units prior to fielding had trouble convincing commanders that a score of 95% of targets killed represented bad performance. That score showed the proportion of targets destroyed, but it did not adequately describe mistakes in "hooking" targets, incorrect application of missiles to non-targets, or the speed (or lack of it) with which the targets were engaged. Commanders were being misled by the single global measure of performance. Another example is TACFIRE's embedded CAI which goes off the air if two format mistakes are made without any indication to the trainee of what he did wrong. Hopefully, the developing ET components for AFATDS, HIP, and ASAS will provide the critical testing capability that can both motivate and evaluate performance.

Implications for Training and ET

Systems and ET

Taken alone, the TACFIRE ET experience would cause doubt whether ET can meet unit requirements to sustain highly perishable skills. Fortunately, Patriot and even the developing Aquila System provide Army system data indicating that ET can give much needed training of perishable operator skills. The TACFIRE ET failure in part reflects a lack of commitment to the technologically outdated TACFIRE System that prevents development of more effective ET packages and also prevents revision of the software that would reduce operator task perishability. Much of this can be explained by the development of TACFIRE's replacement, AFATDS, which will use sophisticated software to make the operator tasks much easier to perform and much less perishable. The TACFIRE problems also reflect inadequate emphasis on sustainment training by Field Artillery Commanders who have not previously faced such alien computer operator tasks that need constant sustainment training even for senior personnel.

The critical role that the TIU is already playing in training military personnel for the Operational Test II provides a preview of how important ET will be for the fielded Aquila System. Only the Patriot System may provide a stronger Army system testimony to the efficacy of ET for sustaining operator

skills. The success of the TIU for Aquila Operational Test II training is predictive of successful unit training with this ET device when Aquila is fielded. Novel scenarios and increased performance measurement will be needed to maximize Aquila's ET potential. More operator feedback and more automatic inclusion of mission problems were planned for the TIU and these would appear to remain important goals.

The Patriot System, to our surprise, had not one but two ET packages. It is interesting to speculate that it was the anticipated striking contrast between the nature of Patriot operator tasks during live fire missions and Patriot operator tasks when no targets are fired on, that led system developers included the two embedded trainers in system specifications. Without ET, the Patriot CRT would show a game where there was no opponent and no opportunity to play even if non-opponents were made believe to be opponents. The Troop Proficiency Trainer fills the first gap and the Live Air Trainer may have been conceived to fill the second.

Aquila and the fiber-optic guided missile (FOG-M) provide an even stronger contrast between the combat and non-combat situation than Patriot. For both systems the video screen would be blank during operations except for the time when the RPV was airborne and the very few minutes of FOG-M flight (Of course, the FOG-M screen is also used to allow mission planning and other operations, including presentation of the embedded training).

This gap between combat and non-combat soldier activity is not new and its recognition has not been recent. It is not a function of soldiers' new practice of fighting the battle while seated in front of CRTs. War games, FTXs, squad tactical training, training devices and numerous other means have been developed over the years to develop combat skills in the absence of combat. However, the advent of microprocessors in weapons systems now allows wargaming to occur on the operational equipment with the relatively small additional cost of appropriate software. This wargaming is particularly easy to achieve when the normal operator stimuli come from computer related displays and the operator's responses are via the controls of the computer. The system developers' decisions to introduce ET in the absence of SOPs or guidelines for ET consideration are perhaps due their recognition that commanders and trainers want to simulate combat activities to make military training as realistic as possible. This is not to say that guidelines for ET are unnecessary since not all system developers are this perceptive and/or motivated.

The requirements for ET in AFATDS, HIP, and ASAS also undoubtedly reflect awareness by the developers of the future dearth of programs for the "television sets" (CRTs) of these weapons systems when the war isn't "on." It also reflects increased recent recognition of ET as a potential sustainment training solution by parts of the development community, including PM-TRADE and ARI. However, there is some question of whether current implementations of ET reflect adequate consideration of operator performance evaluation in addition to training. It is critical that performance assessment be given as high a priority as simulation of combat tasks in the development of ET for these systems.

Half of our fielded systems may be considered not to have ET. What can be learned about ET from these examples? One thing characteristic of aviation systems is that although there is a strong need for training on devices to save aviation fuel and costly ammunition, aircraft are not generally suitable for

having a device mounted on the aircraft that would take advantage of some or all of the operational system, if for no other reason than the problem of added weight. The typical solution to sustainment training of aviators has been training in the operational equipment supplemented by training with simulators and other training devices located at aviation units but not collocated with or dependent on the aircraft.

Although we have discussed BIFV as not having ET, the training devices which use lasers mounted on the vehicle or low-caliber ammunition for gunner training and those devices using strap-on displays that simulate optical sight viewing also meet many of the primary ET criteria (e.g. - using the operational equipment for training) and can be considered ET. Only the Unit Conduct of Fire Trainer which uses a mock-up turret would not depend on the operational equipment for at least part of its training. BIFV's message for ET may be that ET is so typically considered in association with microprocessors, either operational or strapped-on, that ET may not be recognized when it exists in their absence. Further, ET may not be considered for a given system just because it does not contain microprocessors or other computer gear.

Training Applications in Systems

This section summarizes the capabilities and training features of the training applications observed in these eight systems. This is intended to be useful in further examination of what works, what does not and for which kinds of systems. Summarized below are: 1) the characteristics of the training devices found in these eight systems; 2) characteristics of the ET applications found in the systems; and, 3) a crosstabulation of the instructional and equipment technologies applied in three training methods to train systems' key tasks.

Training Device Characteristics: Table 4 describes the major hardware capabilities built into the different institutional/unit training devices available to support training for these systems. These characteristics include menu-driven, trainee-prompting, networking, synthetic targets, synthetic non-targets, smart targets, synthetic audio, synthetic platform motion, synthetic digital messages, synthetic indicator displays, synthetic missile displays operator feedback, portability, single-station, multi-station, and fielded vs. developmental.

Table 5 describes the major training characteristics of the different institutional/unit training devices developed or planned for the eight systems. The training characteristics considered are initial training, sustainment training, cross-training, full-scenario training, part-task training, individual training, team training, canned scenarios, modifiable scenarios, performance measurement, immediate performance feedback, performance data extract, hard copy student performance record, real time replay, and selectable replay.

Embedded Training Characteristics: Table 6 describes the major characteristics of the different ET components that exist for the six Army systems with ET. The ET characteristics considered are integrated ET, strapped-on ET, on-line ET, off-line ET, networking, synthetic targets, synthetic non-targets, smart targets, synthetic audio, synthetic digital messages, synthetic indicator displays, synthetic missile symbols, fielded ET, developmental ET, and operator feedback.

Table 4

Capabilities of Army System Training Devices

Device Capabilities:	Apache				Bradley				TACFIRE	Patriot		AFATDS	Aquila	ASAS		HIP	
	Panel	TSTT	CWPT	CMS	UCOFT	MILES	SAAB	BGMTS		PCOFT	POMT			low	high	FCST	FATMT
Menu Driven	X	X			X						X		X	X	X	X	X
Trainee Prompting		X			X						X		X	X	X	X	X
Networking						X	X								X		
Synthetic Targets		X	X	X	X					X			X			X	
Synthetic Non-Targets		X	X	X	X					X			X				
Smart Targets			X	X													
Synthetic Audio			X	X	X												
Synthetic Motion			X	X													
Synthetic Messages		X	X	X	X					X	X		X	X	X	X	X
Synthetic Displays	X	X	X	X	X					X	X		X	X	X	X	X
Synthetic Missiles		X	X	X						X							
Operator Feedback		X	X	X	X	X	X	X		X	X		X	X	X	X	X
Portable	X	X												X			X
Single Station	X	X	X	X										X			X
Multi-station					X	X	X	X		X	X		X		X	X	
Fielded	X	X	X	X	X	X		X		X	X		X				
Developmental							X					X		X	X	X	X

Table 5

Training Characteristics of Army System Training Devices

Training Characteristics	Apache				Bradley				TACFIRE	Patriot		AFATDS	Aquila	ASAS		HIP	
	Panel	TSTT	CWPT	CMS	UCOFT	MILES	SAAB	BGMTS		PCOFT	POMT			low	high	FCST	FATMT
Initial Training	X	X	X	X						X	X		X	X	X	X	X
Sustainment Training		X	X	X	X	X	X	X									
Cross Training	X	X	X	X	X	X	X	X									
Full Scenario Training			X	X	X	?	?			X	X		X		X	X	X
Part-Task Training	X	X	X	X				X		X	X		X	X	X	X	X
Individual Training	X	X	X	X		X	X	X		X	X		X	X	X	X	X
Team Training			X	X	X	X	X	X		X	X		X		X	X	
Canned Scenarios					X					X	X		X	X	X		
Modifiable Scenarios	X					X	X	X							X		X
Performance measurement		X	X	X	X		X			X	X		X	X	X	X	
Immediate Perf Feedback	X	X	X	X	X					X	X		X	X	X	X	
Performance Data Extract			X	X	X		X			X	X		X	X	X	X	
Hard Copy Student Record					X		X			X			X		X		
Real Time Replay					X												
Selectable Replay	X				X					X			X				

Table 6

Hardware Characteristics of Army Embedded Training Systems

ET System Characteristics:	Patriot TPT	Patriot LAT	TACFIRE Tapes	TACFIRE CAI	AFATDS	Aquila TIU	Aquila SATS	ASAS	HIP
Integrated	X	X	X	X					
Strapped on						X	X		
On-line		X					X		X
Off-line	X		X	X		X	X		
Networking	X	X	X						
Synthetic Targets	X		X	X		X			X
Synthetic Non-Targets	X					X			
Smart Targets									
Synthetic Audio									
Synthetic Digital Messages	X	X	X	X		X			X
Synthetic Indicator Displays	X	X	X	X		X			X
Synthetic Missile Symbols	X	X							
Operator Feedback	X	X	X	X		X	X		X
Fielded	X		X	X		X			
Developmental		X			X		X	X	X

Integrated ET components should ideally require only a software change to provide ET. This contrasts with strapped-on systems which usually require additional microprocessors, computer memory, displays, and/or controls to effect ET. On-line ET occurs while the system is actually operational whereas the more common off-line systems require that the system be switched to the training mode. Strapped-on ET usually is off line, but both Aquila strap-on packages do operate on-line, although, for the SATS, a manned aircraft carries the "strapped-on" television camera or forward looking infrared (FLIR) system.

Networking can be considered in two senses. One is integration of different units into the ET as occurs with both Patriot ET components. Another sense of networking is using additional strap-on (or existing) terminals to provide multiple person training including the possibility of separate ET programs for each trainee. The large computer planned for AFATDS would easily handle this type of networking. No networking in this computer distributed processing sense existed in the eight Army systems studied.

The other ET component characteristics presented in Table 6 are largely self-explanatory. It can be seen that only one of these systems provided ET that was on-line. This was the Patriot live air trainer which uses the system radar and theoretically could be providing operator training even during the last moments prior to an anticipated air strike.

Table 7 describes the training characteristics of the nine different ET components that exist for the eight Army systems which were studied. These characteristics are basically the same as those included in Table 5 and are described above. It can be seen that no ET components allow modifiable scenarios. Aquila's TIU allows different flight paths and different pointings of the sensor package, but the targets are unchanging except for two or three movers and they move in a fixed repeating pattern. As will be described later, this lack of modifiable scenarios and the typical small number of canned scenarios presents a serious sustainment training problem.

Tasks, Training Type and Technologies: Table 8 shows the technology applications believed to exist in the training approaches to key tasks for the eight systems reviewed. This analysis is very preliminary: Some indicated approaches may not actually exist; the definitions need clarification. For now, the table indicates the technologies believed to be applied to training of key tasks under any or all of the three training approaches observed (ET, training devices/simulators and other [conventional] training). The technologies list developed for the ET project (Massey, D., Downes-Martin, S., Harris, M. & Kurland, L., 1985) was supplemented by the list of more conventional training approaches shown in the legend of the table.

This combined data set (Tables 4 through 8) provides a first look at what has been applied in these systems. These data need to be further evaluated to determine what has really worked and what has not. This evaluation should be done as part of the subsequent "crosswalk" stage of the project. This would begin development of the basis for generalizations and extrapolations about the technologies desirable in ET and other training approaches in future systems' applications.

Table 7

Training Characteristics of Army Embedded Training Systems

ET Training Characteristics:	Patriot TPT	Patriot LAT	TACFIRE Tapes	TACFIRE CAI	AFATDS	Aquila TIU	Aquila SATS	ASAS	HIP
Initial Training				X					X
Sustainment Training	X	X	X	X	X	X	X	X	X
Cross Training									
Full Scenario Training	X		X			X	X		X
Part-Task Training	X	X	X	X		X	X		X
Individual Training	X	X	X	X		X	X	X	X
Team Training	X	X	X			X	X	X	X
Canned Scenarios	X		X	X		X			
Modifiable Scenarios							X	X	
Performance Measurement				X				X	X
Immediate Performance Feedback								X	X
Performance Data Extract	X		X	X					X
Hard Copy Student Record				X				X	
Real Time Replay						X	X		
Selectable Replay						X	X		

Table 8

Technology Areas Used for Training of Key Tasks

Instructional and Training Technologies:

EQ	-- Actual equipment training	SSP	-- Sound-slide presentations
O	-- Observation of skilled performance	W	-- Written instructional materials
F	-- Film or videotape demonstrations	L	-- Lectures and demonstrations
ASR	-- Analog image storage and retrieval	CBI	-- Computer Based Instruction
DMV	-- Digital storage/manipulation of video imagery	SP	-- Symbolic processing
CGI	-- Computer-generated imagery	LSD	-- Large-scale digital storage
SS	-- Speech synthesis	LB	-- Laser "bullets" and detectors
SR	-- Speech recognition		

Key Operator Tasks:	Training Alternatives: Embedded Training	Training Devices/ Simulators	Other Training/ Instruction
BIFV Tasks			
Target surveillance from BIFV	NA	ASR,CGI,CBI,LSD	EQ,L
Operate BIFV 25-mm chain gun	NA	LB,ASR,CGI,CBI,LSD	EQ,L
Operate BIFV coaxially-mounted machine gun	NA	LB,ASR,CGI,CBI,LSD	EQ,L
Operate BIFV TOW missile	NA	LB,ASR,CGI,CBI,LSD	EQ,L
Aquila Tasks			
Input data into Aquila computer		CBI	EQ,W,L
Remotely guide vehicle and sensor payload	CGI,LSD	DMV,LSD	EQ,W,L
Remote laser-designation of targets	CGI,LSD	DMV,LSD	EQ,W,L
Target surveillance (video/CRT display)	CGI,LSD	DMV,LSD	EQ,F,L,SSP
Lock optical contrast tracker onto target	CGI,LSD	DMV,CBI,LSD	EQ,W,L
Assess damage from artillery/other munitions	CGI,LSD	CGI,DMV,LSD	EQ,F,L,O
Plan RPV missions	CGI	CGI,CBI	EQ,W,L
Transmit/receive digital messages via computer			W,L
Apache Tasks			
Fly Apache helicopter	NA	DMV,CGI,CBI,LSD	EQ,W,L
Operate helicopter weapons systems	NA	DMV,CGI,CBI,LSD,LB	EQ,W,L
Laser designation of targets	NA	DMV,CGI,CBI,LSD,LB	EQ,W,L
Maintain helicopters	NA	LSD,CBI	EQ,W,L,F
Patriot Tasks			
Monitor target/nontarget symbology on PPI	CGI,LSD	CGI,LSD	EQ,W,L
Select air defense targets for engagement	CGI,LSD	CGI,LSD	EQ,W,L
Maintain Patriot System		CBI,LSD	EQ,W,L
AFATDS Tasks			
Operate AFATDS computer and peripherals	LSD	LSD	EQ,W,L
Perform organizational maintenance			W,L
Repair AFATDS System			W,L

Table 8

Technology Areas Used for Training of Key Tasks (Continued)

Instructional and Training Technologies:

EQ	-- Actual equipment training	SSP	-- Sound-slide presentations
O	-- Observation of skilled performance	W	-- Written instructional materials
F	-- Film or videotape demonstrations	L	-- Lectures and demonstrations
ASR	-- Analog image storage and retrieval	CBI	-- Computer Based Instruction
DMV	-- Digital storage/manipulation of video imagery	SP	-- Symbolic processing
CGI	-- Computer-generated imagery	LSD	-- Large-scale digital storage
SS	-- Speech synthesis	LB	-- Laser "bullets" and detectors
SR	-- Speech recognition		

Key Operator Tasks:	Training Alternatives: Embedded Training	Training Devices/ Simulators	Other Training/ Instruction
HIP Tasks			
Operate HIP fire control system			W,L
Monitor/relay and record fire commands			W,L
Operate communications system			EQ,W,L
Drive M109E5			EQ,L,W
Operate ammunition loader			EQ,L,W
Assemble various on-board munitions			EQ,L,W
TACFIRE Tasks			
Operate and maintain 15KW/42KW Generator Sets			EQ,L,W
Operate Variable Format Message Entry Device	CBI		EQ,L,W
Operate TACFIRE computer	CBI	NA	EQ,W,L
Initiate/process fire missions TACFIRE computer	CBI	NA	EQ,W,L
Process specific function reports	CBI	NA	EQ,W,L
Identify/correct error messages	CBI	NA	EQ,W,L
Display Mission data on Digital Plotter		NA	EQ,W,L
ASAS Tasks			
Manipulate data for Corps, Div and Bde	CBI	NA	EQ,W,L
Analyze specific area intelligence data	DMV,CGI,CBI	DMV,CGI,CBI	EQ,W,L
Correlate, extrapolate and draw conclusions from intelligence data			EQ,W,L
Draw from existing intelligence databases			EQ,W,L
Manipulate intelligence data through alphanumeric and graphics capability	DMV,CGI,CBI	DMV,CGI,CBI	EQ,W,L
Create new intelligence databases	CBI,LSD	CBI	EQ,W,L
Send information	CBI	CBI	EQ,W,L
Respond to requests for information			EQ,W,L
Asset tasking for additional information	CBI	CBI	EQ,W,L
Evaluate new information	CGI	CGI	EQ,W,L

Training Effectiveness and Cost Effectiveness of Embedded Training

When attempting to discuss the effectiveness of embedded training as observed in these eight systems, two points must be kept in mind:

1) these systems are very diverse with respect to their missions, operator tasks and stage of development - this diversity makes it difficult if not impossible to derive general statements about effective and cost effective ET from these system examples; and,

2) the training systems observed (including the ET components) appear to fall on a continuum of training system integration into the operational systems - from the Apache system (with multiple training devices, but little actual integration into the aircraft flight or ground training operations), through the Bradley (with no microprocessors, but several strap-on training devices), through the strap-on ET of Aquila (the TIU and SATS), to the Patriot (where ET is in the system's computer).

This observed continuum of training systems applications may have significant implications for the total acquisition process and for the consideration of ET within that process. The continuum may be more extensive than yet observed. Perhaps all training approaches should be considered in terms of this continuum - with group-presented, hands-off, lecture-demonstration instruction at one end of the continuum and completely embedded, automated, computer-aided, computer-managed, and expert-system-aided instruction, in the operational system, at the other end.

Under this concept, training devices and simulators, for example (not to mention training and job performance aids - why muddy the waters further?), should be considered one (or two) point(s) on the continuum of potential training alternatives, between the two extremes. Thus, embedded training, exactly like classroom instruction and training devices, would be considered as one possible training approach for application to the specific training system development at hand.

If this concept were generally recognized and accepted by system and training developers, it could be usefully applied to the initial (and subsequent) consideration of training needs and developments. Thus, the concept might lead to broader early conceptualization of training system alternatives and, hopefully, to more effective training systems developments.

In general, and in most specific cases, training effectiveness and the cost effectiveness of training are major concerns to the Army and to all who work to support the continued operational readiness of our armed forces. Training effectiveness - the demonstrable improvement of operational task and mission performance as a direct effect of training experiences - and cost effectiveness - the achievement of effective training at the most reasonable cost expenditures - are continually sought by systems and training developers as well as by operational commanders and politicians. These concerns apply to all training: institutional and unit, training device and simulator, lecture/demonstrations or embedded training; the aim is to achieve cost effectiveness in all instances.

Therefore, the effectiveness and cost effectiveness of embedded training are important considerations for the potential development and implementation

of this unique tool for sustainment training. The third point which must be added to the two above is that relatively little can be said about these considerations at this time. This is largely because we do not have very good information about these aspects of embedded training, or, indeed, of any training. Although cost and training effectiveness have received considerable emphasis over the past two decades, little hard data are available from the agencies which have studied it. TRASANA (the TRADOC systems analysis activity) is the Army's focal agency for cost and training effectiveness analysis of existing and developing systems. TAEG (the Technical Analysis and Evaluation Group) is the Navy's prime agency for developing and applying methods for cost and training effectiveness analysis and evaluation. Both agencies have developed methods and performed studies on numerous systems, training systems, training programs and training devices over the years. However, the methods for such studies and the hard data resulting from these studies are still incomplete, inconclusive and, in some cases, inadequate to the needs.

A major difficulty in achievement of cost effective training (which is also training effective) is the lack of a body of data which demonstrates what types of training are truly (most) training effective for which types of tasks. We, the researchers, training practioners and training developers, cannot point to clear-cut empirical data indicators that say "train this task this way, for this period of time (or these repetitions), and you will achieve this level of task performance in the field". We are unable to specify to the operational personnel, the combat developers and the systems engineers what to build into the system and its training program to achieve the desired performance. Since we cannot so specify the training program, we are unable to help the engineers define what the training program should cost to produce effective training.

The second difficulty is in the area of methods for costing training and evaluating effectiveness payoffs (benefits of training). Cost effectiveness of military training has been examined in multiple ways and with many different models over the years. TAEG has done some highly detailed costing models for institutional training, while TRASANA developed the "textbook" for Cost and Training Effectiveness Analysis (CTEA) and for Training Development Studies (TDS) as a form of CTEA. Similarly, studies such as The Battalion Training Study by FORSCOM and the 4th Infantry Division's study of effectiveness of training with various reductions of resources (1979-81) are examples of attempts to evaluate the cost and effectiveness of unit training. Also, the Army Training Study (ARTS - TEA) headed by GEN R. Brown, (1977-78) attempted this for the entire Army training system. Other agencies, including ARI - the Fort Bliss and Fort Benning Field Units in particular, have also done work on CTEA and training effectiveness. However, with all this work, the state of the art is still inadequate to the need. Because of the limitations of cost effectiveness methods and the incompleteness of the training effectiveness data base, questions about the cost effectiveness of embedded training (or any training) cannot be answered definitively.

Given this situation, systems developers have consistently ignored pure training effectiveness and have striven to develop training systems, devices and programs that do train (to some level), generally at the lowest possible cost. Simultaneously, combat developers and training developers in the Army Branches have striven to produce the most realistic and most complete training possible for the operational forces. This leads to conflict in training systems development, and especially in training device and training hardware development: the users are accused of wanting to "goldplate" training and

training devices by including all possible realism and all potential system functions; and, the developers are accused of not being willing to pay the "necessary" price for "necessary" training embellishments. Without adequate methods or data with which to evaluate either the actual effectiveness of the training or the benefits of the costs paid, the Army remains in a dilemma.

Because of this situation, empirical research on both cost effectiveness modeling and training effectiveness measurement are required before the cost effectiveness of embedded training can be accurately assessed in relation to other unit training approaches. Such research should address at least the issues listed below:

1) Major Issues:

a. How can Life Cycle training cost-effectiveness be determined for Army training and for unit sustainment training in particular?

b. Can a single form/mode of training be shown to be maximally cost effective in the actual environment and under normal peacetime training conditions? If so, what mode excels and to what degree?

c. Alternatively, can a combination of training modes (combinations of standard training, simulators/devices and ET) be shown to be maximally effective for a given system's training?

2) Derivative Issues:

a. What approach to CE (models or methods) is best applicable to determination of CE for ET?

b. How can sufficient and accurate training data be collected in sufficient types and amounts to be meaningfully used in CE?

c. How can sufficient and accurate soldier performance data be collected in sufficient types and amounts to be meaningfully used in CE?

d. What types, and how much, training cost data can be collected for use in CE methods? Can any cost data be related to specific training and to specific systems trained by specific training methods?

The third major issue listed above, 1) c.,is a quite valid issue that should definitely be addressed in such research. However, it raises some formidable problems. Training Effectiveness (TE) for any training method is usually measured in a relative fashion: the TE of a device <u>as compared to</u> another mode of training; the effectiveness of a simulator <u>as compared to</u> the standard training in the actual equipment; etc.. Similarly, most comparisons are drawn between two alternative training modes rather than more (some studies compare several alternatives, but more than three or four such alternatives are rarely used). In parallel, cost effectiveness studies are usually relative comparisons of some few alternatives. Thus, when one discusses cost effectiveness of training modes, or training effectiveness of training alternatives, one is usually talking about the <u>relative</u> values of these for each alternative. What is probably needed to address the issues above appears to be something other than this simple relative comparison.

To address the above issue, the research goal should be to determine how to achieve the optimal training mix for a given training situation; this must be based on an overall cost effectiveness evaluation of the various modes within such a training mix. The matrix below is intended to represent this concept in terms of the end distribution (or percentage allocation) of training resources to training methods/modes and training site - theoretically this end distribution would be done on the basis of the demonstrated overall effectiveness of that mix of training, based on a "minimax-type" solution for the cost effectiveness of each training mode, at that site, relative to each and all of the other training alternatives (and relative to training the defined tasks with other alternatives at other alternative sites). The figures in the matrix are purely hypothetical guesstimates for some unknown system, and the question marks represent proportions that are unknown but should be developed by research:

Training Mix of Training Methods/Modes

	Actual Eq. Trng	TDs/Simul. Trng	Embedded Trng	Other Trng (Clsrm, ETM)	% Total
Inst'n	25% / 10%	30% / 85%	10% / 10%	35% / 90%	(100%) ??
Unit	30% / 90%	10% / 15%	45% / 90%	15% / 10%	(100%) ??
Total	(100%) ??	(100%) ??	(100%) ??	(100%) ??	100%

This problem, the determination of the most cost effective mix of training, has not apparently been addressed successfully as yet. The only known attempt was an aborted effort to determine the best mix of training in units combining TEC (the Training Extension Courses) with other forms of unit training to achieve individual proficiency as measured by the SQTs. This effort was initiated by the Fort Benning Field Unit of ARI in 1979 with support from USATSC, but failed to obtain the required support from TRADOC and FORSCOM. Although some promising theoretical approaches were generated and studies were defined to verify some of the theory, the effort was dropped in 1981 with no success.

Whether a successful study of this problem can be conducted is dependent on the level of resources and Army support which can be generated. This research will require a relatively high level of effort and considerable expertise. It will also demand extensive Army School and unit support if it is to have any chance for success. Answering this question will be more difficult and therefore more costly than the comparatively simple one of determining the relative cost effectiveness of ET vs. another, or several training mode(s).

SPECULATIVE CONCLUSIONS

This section is titled "Speculative Conclusions" for two reasons:

1) The conclusions are prefaced by "speculative" because HSI does not feel that sufficient data are yet available to "validate" many of these statements; and,

2) The statements needed to be made at this time, even without full supporting data: some of the following may be important in guiding future efforts toward ET guidelines, specifications and standards; other statements should perhaps only be treated as food for thought as we continue the ET project.

System type and ET Consideration/Implementation

* Some Branches (ADA, FA) are more amenable / likely to entertain, support, use ET than other Branches.

* Some system "types" are likely to be more appropriate for ET than others - e.g.:

  - Computer based or supported systems

  - Systems with personnel supply/resupply (pipeline) problems

  - Systems requiring mostly cognitive (vs. psychomotor) tasks of operator/maintainer personnel (perishability)

* For any system some tasks pose greater requirements for ET:

  - Mainly those of high perishability (cognitive, decisioning)

  - Those tasks requiring battle-relevant inputs / demands for efficient training on the system

* Weight has been reported as a limiting factor use of embedded training in aviation systems.

* Difficulty of simulating key visual stimuli and key motion stimuli is another limiting factor in the use of embedded training in aviation systems.

* A tradition of training devices separated from actual aircraft (mainly a safety consideration) may be an inhibiting factor to use of embedded training in aviation systems.

* There is a tendency to think that systems without computers are not candidates for embedded training: however, several of the Bradley's training devices operate much like ET.

* Systems for which the operators get all of their input about the battle from CRTs or other displays are frightfully boring when there is no battle. A built-in or strap-on simulation capability can solve this problem.

System Development and ET Consideration/Implementation

* Very early consideration of embedded training is needed when ET may require strap-ons or is otherwise difficult to implement since system modification will be required. (However, the only way that a system can be classified as being easily adapted for embedded training is through early consideration.)

* If system characteristics lead to difficult and highly perishable tasks like TACFIRE's computer, then system development should include hardware and software modifications to reduce task difficulty/perishability rather than depending on training to solve the problems. Embedded training, like all training, should be the last resort to solve operating problems, not the first.

Training Effectiveness Problems and ET Consideration/Implementation

* Where perishability of skills to operate equipment is a critical factor in operational readiness, job-site sustainment training is necessary.

* If operational equipment can provide sustainment training there may be space, time and/or dollar savings over use of other means - (savings are dependent on, at least, RAM, operating costs, availability and the relative effectiveness of the alternative training means).

* Performance assessment is an essential element in embedded training systems for identification and elimination of training problems and increasing training effectiveness.

Characteristics of Effective and Ineffective ET

* Simulations of combat stimuli and responses are critical for effective embedded training.

* Embedded training simulations of combat stimuli and responses have sometimes been well implemented in current Army embedded training components - this must be a continuing concern of training and system developers.

* Embedded testing or evaluation is at least as critical as simulation for effective training where system feedback is inadequate.

* Performance assessment (embedded or otherwise) has been neglected in Army weapon systems developments - Current ET systems lack systematic evaluation - individual or team - and have virtually no performance assessment capability.

Implications for LCSMM and ET Consideration/Implementation

Army System Developers' Education Needs

* Army system developers need more awareness of:

  - the requirements for sustainment training and the greater need for sustainment training for perishable tasks.

  - the requirement for performance assessment and feedback and its relationship to successful training;

* Army system developers need more detailed knowledge of:

  - the sources of combat stimuli for system operators and their implications for design and development of training systems;

  - the technologies available for embedded training and how they relate to the stimulus sources to be simulated.

LCSMM Input Requirements

1) When?

* As early as humans are seen as potential operators of the system, their training should be considered including the possibility of embedded training for the critical sustainment training of operator skills.

2) Where?

* At all stages of the LCSMM, especially in the hardware concept design stages since consideration and inclusion of embedded training here can allow building the training in "from the ground up" and thus reduce the necessity for later modifications for successful implementation.

3) Why?

* So that continual sustainment training for tasks that need this can allow operational readiness of the system to be maintained at maximum.

* So that dependence on institutional training for cross and transition training can be reduced.

* So that dependence on remotely located training devices for sustainment training can be avoided.

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APPENDIX A

AH-64 APACHE ATTACK HELICOPTER

CONTENTS

CONTENTS (continued)

APPENDIX A

AH-64 APACHE ATTACK HELICOPTER

WEAPONS SYSTEM CHARACTERISTICS

1. Type of System:

Advanced Attack Helicopter

2. System Components and Functions:

a. Engines and Related Systems

The helicopter is powered by two horizontally-mounted turbo-shaft engines. The T700-GE-701 engine is a front-drive, turbo-shaft engine of modular construction. One engine is housed in an engine nacelle on each side of the fuselage aft of the main transmission above the wing. The engine is divided into four modules: cold section; hot section; power turbine section; and, accessory section. Power is supplied to the main transmission through engine-mounted nose gearboxes, shafts, and over-running clutches. The main transmission drives the main and tail rotors and accessory gearbox. Related systems include: Engine and Engine Inlet Anti-Icing System; Engine Fuel Control System; Electrical Control Unit; Fuel Pressure Warning System; Engine Oil System; Engine Emergency Oil System; Engine Chip Detector; Ignition System; Engine Starting System; Infrared (IR) Suppression System; Engine Control System; and, Engine Instruments (Department of the Army [DA], 1984d; US Army Aviation Center [USAAVNC], 1985n).

b. Fuel System

The fuel system provides fuel and fuel management provisions to operate both engines and the auxiliary power unit (APU). Fuel is stored in two crash-resistant, self-sealing fuel cells: one forward and one aft of the ammunition bay. Fuel may be transferred from either cell to the other. The system is also equipped to crossfeed (select which fuel cell supplies fuel to the engines). The helicopter has provisions for carrying either two or four external fuel tanks on the wing pylon attachment points (DA, 1984d).

c. Flight Controls and Automatic Stabilization Equipment

The flight control system consists of mechanical flight controls, digital automatic stabilization equipment (DASE) and an automatically or manually controlled stabilator. The mechanical flight controls provide a cyclic stick, collective stick and directional pedals in each crew station, connected in tandem, to provide control inputs to the main and tail rotor hydraulic servoactuators. A mixing unit combines inputs from the servoactuators and transmits them to a non-rotating swashplate. The swashplate changes the linear motion from the mixer unit to rotating motion. The swashplate provides pitch changes for the four main rotor blades. Pedal inputs are transmitted in a

similar manner to the tail rotor blades, except the mixer unit is not required (DA, 1984d).

The cyclic sticks, one in each crew compartment, provide for helicopter movement about the pitch and roll axes. The co-pilot/gunner's (CPG) stick has a lockpin release mechanism at the base of the stick. This allows the CPG to fold the stick down while viewing the heads-down display and provides greater ease of ingress/egress. Both cyclic stick grips have switches for weapons firing, DASE disengagement, trim feel, radio and intercommunications and flight mode symbology. The pilot's grip also has a remote transmitter selector switch for radio selection (DA,1984d; USAAVNC, 1985t).

The collective sticks in both crew stations provide the crew with a means of adjusting pitch angle of the main rotor blades and furl flow metering requirements of the gas generator engines. A switch panel at the end of each collective stick contains switches for two searchlights, guarded wing stores jettison, radio frequency override, night vision system and boresiting (DA,1984d; USAAVNC, 1985t).

The digital automatic stabilization equipment (DASE) augments flight stability and enhances maneuverability of the aircraft. DASE includes and/or controls the following: stability and command augmentation in pitch, roll and yaw; attitude hold; heading hold; hover augmentation; turn coordination; and, the back-up control system (BUCS). The automatic stabilization system control panel, located in the pilot's left console, has five magnetic switches and a BUCS start switch (DA, 1984d; USAAVNC, 1985u).

d. Hydraulic Systems

Two independent hydraulic systems are installed so that failure of one system will not affect operation of the other. They are similar but not identical; they have separate, as well as shared functions.

The primary hydraulic system provides hydraulic power to the primary side of the lateral cyclic, longitudinal cyclic, collective and directional servoactuators. Only the primary side of these servoactuators has electrohydraulic valves that allow the DASE and BUCS to affect the flight controls Consequently, failure of the primary hydraulic equipment includes the hydraulic pump, manifold, servoactuators and heat exchanger (DA, 1984d; USAAVNC,1985l).

The utility hydraulic system provides hydraulic power to the utility side of the lateral cyclic, longitudinal cyclic, collective and directional servoactuators. This system also provides power to the rotor brake, area weapons system, external stores, tail-wheel lock, ammo carrier drive and APU starter. The utility hydraulic pump and heat exchanger are identical to the primary system. The only significant difference between the two systems is the manifold. Two additional components in the system are the accumulator and the rotor brake (DA, 1984d; USAAVNC, 1985l).

e. Power Train

The power train transmits engine power to the rotors and transmission mounted accessories. The power train includes two engine nose gearboxes, two shafts to the main transmission, the main transmission, main rotor drive shaft, tail rotor drive shafts, intermediate gearbox, tail rotor gearbox, auxiliary power unit (APU) drive shaft and couplings (DA, 1984d; USAAVNC, 1985p).

f. Main and Tail Rotor

The rotor system consists of a single, four-bladed, fully articulated main rotor and a four-bladed tail rotor assembly with tow teetering rotor hubs (DA, 1984d; USAAVNC, 1985q).

g. Utility Systems

Multiple anti-icing and de-icing protection is available for the windshields, pitot tubes, air data sensor, pilot night vision sensor (PNVS), target acquisition and designation sight (TADS), engine inlets, nose gearboxes and main and tail rotor blades. The 30 mm weapon and the wing pylons are also susceptible to icing and may be de-iced by periodic flexing in azimuth or elevation. The pilot and CPG have ANTI-ICE panels on their left consoles (DA, 1984d; USAAVNC, 1985s).

h. Environmental Control System

Crew compartment ventilating, heating and air conditioning are provided through an environmental control system (ECS). The ECS is also the primary source of cool air for the two forward avionics compartments. The ECS is comprised of the environmental control unit (ENCU), ECS control panel, manifolds and tubing to deliver pressurized air to the ENCU and ducting to route conditioned air form the ENCU to the crew stations, forward avionics bay and TADS/PNVS turret (DA, 1984d).

i. Electrical Power System

All the helicopter electrical power requirements are supplied by two AC generators, two transformer/rectifiers and, in the case of complete failure, a 24-volt battery will supply flight critical systems. For ground operation, 115 vac external power can be supplied to the helicopter through the external power receptacle.

The ac power supply system is the primary source of electrical power. It supplies 115 vac, 400 hertz, from two 35 kilovolt-ampere generators. Each generator and its associated components comprise an independent ac generating system that supplies about one-half of the total electrical requirements to the ac buses. If one generator fails, its load is automatically connected to the remaining generator (DA, 1984d; USAAVNC, 1985i).

Two buses are supplied by power from the two 350 ampere transformer/rectifiers via circuit breakers. The transformer/rectifiers

convert the alternating current input to 28 volts direct current (vdc) which is applied to a contactor and routed to two dc buses. The 28 vdc is then routed, in parallel, through isolation diodes to power the direct current emergency bus during normal operation. For emergency operation, the battery powers the direct current emergency bus (DA, 1984d; USAAVNC, 1985i).

j. Auxiliary Power Unit

The auxiliary power unit (APU) indirectly provides hydraulic, pneumatic and electrical power for the operation of helicopter systems whenever the engines are not driving the main transmission accessory section. The APU provides the means of engine starting without the need for a ground power unit (DA,1984d; USAAVNC, 1985m).

k. Lighting System

The aircraft lighting system consist of exterior and interior lighting systems. The aircraft exterior lighting system consists of formation lights, navigation lights, anticollision lights, a searchlight and an inspection maintenance light (DA, 1984d; USAAVNC, 1985i). The helicopter interior lighting system consists of dimming lighting for engine instruments, flight instruments, avionics panels, console panels and circuit breaker panels. All engine and flight instruments are equipped with red surface-mounted edge lighting fixtures, and the avionics console and circuit breaker panel lights are integrally illuminated. Light is reflected to illuminate the panel markings and the clear edging around each switch and circuit breaker. In the event of total electrical power generation failure, the pilot and CPG flood lights, utility lights and searchlights remain operable through the emergency bus (DA, 1984d; USAAVNC, 1985i).

l. Flight Instruments

The instruments mentioned are, for the most part, those that measure flight performance. Not all flight instruments are common to both crew stations. The flight instruments found in both crew stations are the barometric pressure altimeter, instantaneous vertical speed indicator, airspeed indicator, altitude indicator and clock (DA, 1984d).

The flight instruments found only on the pilot instrument panel are the video display unit, magnetic compass, free air temperature gauge, accelerometer and radar altimeter. The only flight instrument peculiar to the front crew station is the radio magnetic indicator (DA, 1984d).

m. Avionics

The communications equipment provides VHF-AM/FM and UHF-AM capabilities. The navigation equipment includes LF-ADF and Doppler. Transponder equipment consists of an IFF receiver-transmitter.

(1) Communications:

(a) Intercommunication System C-10414/ARC

Provides intercommunication capability between the pilot and CPG (DA,1984d; USAAVNC, 1985x).

(b) Radio Set AN/ARC-186\9v\0

This is a VHF FM-AM transceiver that provides clear and secure voice communication capabilities in VHF, AM and FM bands over a frequency range of 108.00 to 151.975 MHz with channel spacing of 25 kHz which provides up to 2,320 voice channels. It also provides 20 channel presets which can be any combination of AM or FM frequencies. Automatic tuning of both FM and AM emergency frequencies is provided by setting only one control. Power output is rated at 10 watts (DA, 1984d; USAAVNC, 1985x).

(c) Radio Set RT-1167/ARC-164(V)

This is an airborne, UHF AM, radio transceiver set. It contains a multichannel, electronically tunable transceiver and a fixed-tuned guard channel receiver. The transceiver operates on any one of 7,000 channels spaced in 0.025 MHz units in the 225.00 to 399.750 MHz UHF military band. The radio set is primarily for voice communications (DA, 1984d; USAAVNC, 1985x).

(d) Voice Security System TSEC/KY-28

This equipment is used to provide voice transmission security (DA, 1984; USAAVNC, 1985x).

(2) Navigation:

(a) Direction Finder Set AN/ARN-89

This is an airborne, low frequency (LF), automatic direction finder (ADF) radio that provides an automatic or manual compass bearing on any radio signal within the frequency range of 100 to 3000 kHz. The ADF displays the helicopter bearing relative to a selected audio transmission (DA, 1984d; USAAVNC, 1985x).

(b) Lightweight Doppler Navigation Set (LDNS) AN/ASN-128

This set, in conjunction with the heading and attitude reference set (HARS), provides helicopter velocity, position and steering information from the ground level to well above 10,000 feet. The LDNS is a completely self-contained navigation system that does not require any ground-based aids. The system provides world-wide navigation with position read-outs available in both Universal Transverse Mercator (UTM) and Latitude/Longitude (LAT/LONG). Navigation. Steering is done using LAT/LONG coordinates and a bilateral UTM-LAT/LONG conversion routine is provided for UTM operation. As many as ten destinations may be entered in either format and not necessarily the same

format. Present position data entry format is also optional and independent of destination format (DA, 1984d; USAAVNC, 1985x).

(c) Altimeter Set AN/APN-209(V)

The system provides instantaneous indication of actual terrain clearance height. Altitude, in feet, is displayed on a radar altimeter on the instrument panel in front of the pilot (DA, 1984d; USAAVNC, 1985x).

(d) Heading and Attitude Reference System (HARS)

This system is a self-contained inertial platform which provides the pilot with attitude signals for pitch, roll, heading, velocities and accelerations. All signals are sent to the MUX for use by the fire control computer and other systems such as DASE, navigation, stabilator and symbology. The visual display unit (VDU) and the helmet display unit (HDU) display this information to the pilot (DA, 1984d; USAAVNC,1985x).

(3) IFF Transponder

The Transponder Computer KIT-1A/tsec is the Interrogate-Friend-or-Foe (IFF) system aboard the helicopter. This is a classified system (DA, 1984; USAAVNC, 1985x).

n. Helicopter Mission Avionics

(1) Air Data Sensor Subsystem (ADSS)

This consists of an omni-directional airspeed sensor (OAS) and air data processor (ADP). The OAS measures the airspeed and temperature. The ADP senses static pressure and, with the data from the OAS, calculates the air mass data required for fire control (DA, 1984d; USAAVNC, 1985x).

(2) Fire Control Computer (FCC)

The FCC is the primary bus controller. The FCC controls all data transmissions on the multiplex during normal operations. The FCC processes and computes data for all fire control capabilities on board the helicopter. It continuously executes internal built-in tests and in the event of a failure signals the BBC below to assume control of the bus. It operates on 115 vac and 28 vdc current (DA, 1984d; USAAVNC, 1985x).

(3) Backup Bus Subsystem (BBC)

This is part of the CPG's multiplex remote terminal units (MRTU). The BBC monitors the primary bus controller for faults during normal operation. The BBC automatically assumes control of the multiplex bus when it senses a failure of the fire control computer (FCC). When the BBC is the primary bus controller, several fire control operational capabilities are not available. They are: Gun and Rocket ballistic solutions; Fault Detection/Location System (FD/LS); and, Waypoint/Targeting. All other fire control capabilities are

available and function identically as under FCC bus control (DA, 1984d; USAAVNC, 1985x).

(4) Multiplex Bus Subsystem (MUX)

This subsystem consists of multiplex remote terminal units (MRTU) and a redundant data bus. The MRTUs are used to interface the various subsystems on board the helicopter. Three helicopter subsystems, the digital automatic stabilization equipment (DASE), the remote HELLFIRE electronics (RHE) unit and the symbol generator, also function as MRTUs. The data bus consists of two identical bus networks separated down each side of the helicopter and interconnected in such a manner that loss of data communications is minimized or avoided in the event of battle damage (DA, 1984d; USAAVNC, 1985x, 1985v).

(5) Integrated Helmet and Display Sight Subsystem (IHADSS)

The subsystem consists of the crew member helmet (a helmet display unit [HUD] and sight survey units [SSU]), display adjust panel (DAP) and a boresight reticle unit (BRU), all located in each crew station and the sight electronics unit (SEU) and display electronics unit (DEU), located in the left forward avionics bay. The sight survey units, in conjunction with the sight electronics unit, determine the crew member's line of sight (LOS). The weapons and sensor turrets can be directed by either crew member's LOS. The Helmet display unit (HUD) consists of a CRT with optical elements which project the selected 6y.symbology and sensor imagery onto a combining lens. The HUD is attached to the right side of the helmet during normal use. The attached HUD is rotated in front of the right eye for viewing of the display or can be rotated vertically away from the eye when not in immediate use. The display electronics unit provides power and video signals to each crew member's HDU through the display adjust panel (DAP). The DAP is used to adjust image size, centering and electronic focus as it appears on the combining lens and is located in each crew compartment., The boresight reticle unit in each cockpit is used to boresight the crew member helmet (DA, 1984d; USAAVNC, 1984a, 1985c, 1985e).

(6) External Stores Subsystems (ESS)

The ESS consists of an external stores controller and up to four pylon assemblies. The ESS commands the pylons to the required elevation angles for the various fire control modes. The modes are: ground stow; flight stow; and, FCC control (DA, 1984d; USAAVNC, 1985bb).

(7) Symbol Generator

The symbol generator receives data from the bus controller and creates the symbols on the video image. The symbol generator also serves as the video switching unit for the helicopter. The symbol generator receives incoming video from the TADS, PNVS and video recorder and routes them to crew stations as requested by the crew members. It will display video and symbology or symbology only on any of the displays: IHADSS; TADS ORT: or VDU (DA, 1984d; USAAVNC, 1984a, 1984b, 1985f).

(8) Radar Signal Detector Set AN/APR-39V-1

This set detects and displays the total radar environment in which the helicopter is operating. Each radial strobe on the display is a line of bearing to an active emitter. The set is capable of discriminating between high and low band radar emitters to differentiate ADA radar from other radar sources (DA 1984d; USAAVNC, 1985x).

(9) Radar Jammer Set AN/ALQ-136

The radar jammer automatically provides jamming power to the transmit antenna upon receipt of threat radar energy at the receive antenna (DA, 1984: USAAVNC, 1985x).

(10) Pilot Night Vision Sensor (PNVS) AN/AAQ-11

The PNVS is used by the pilot for externally aided vision at night or during adverse weather. The PNVS consists of a stabilized Forward Looking Infrared Radar (FLIR) contained in a rotating turret mounted above the Target Acquisition/Designation System (TADS) in the nose of the helicopter. When selected, the turret is slaved to the crew member helmet LOS. This is accomplished using the IHADSS which also presents the FLIR image and symbology video to the crew member on the helmet mounted display (HMD). The PNVS image and symbology can also be displayed on any of the helicopter displays through switching. Normal operation calls for the pilot to have control of the PNVS turret; however, in the event of pilot incapacitation, the CPG can exercise turret control (DA, 1983a, 1984a, 1984c; USAAVNC, 1985y).

The PNVS flight symbology has four modes: cruise; transition; hover; and, bob-up. Modes are selectable using the flight symbology mode switch on the cyclic stick. There are a total of 23 different symbols used in the four symbology modes (DA, 1984d; USAAVNC, 1985f).

(11) Video Recorder Subsystem (VRS)

The VRS consists of an airborne video recorder and has the capability of recording either the pilot or CPG selected video. Capability exists for playback onboard the helicopter for real time damage assessment and reconnaissance. The video tape recorded onboard the helicopter requires a special video playback unit with a slower than normal playback capability, to view the imagery from the helicopter video recorder. The standard video cassette recorder (VCR) will not play back at a sufficiently slow speed to view the imagery (DA, 1984a; Utley, 1985).

(12) Target Acquisition Designation Sight (TADS) AN/ASQ-170

The TADS provides the CPG with day and night target acquisition by means of any one of: direct view optical telescope (DVO); day television (DTV); forward looking infrared radar (FLIR); or, laser spot tracker (LST). After target acquisition, the CPG can then use the Laser Rangefinder/Designator (LRF/D) to range or spot the target.

The sensors may be used alone or in combination, depending on the tactical, weather and visibility conditions. Target tracking may be accomplished manually, automatically (using the image auto-tracker [IAT]) or by using the laser spot tracker (LST). The laser spot tracker facilitates tracking the reflected laser energy of the proper code. The image auto-tracker has the capability to offset track one target, while automatically tracking another target. The Laser Rangefinder/Designator provides range information for display and fire control solutions and enables the CPG to designate an object for terminal guidance of laser guided weapons. The DVO has wide and narrow fields of view. The DTV has wide, narrow and zoom fields of view. The FLIR has wide, medium, narrow and zoom fields of view (DA, 1984d; USAAVNC, 1985d).

(13) Weapon Symbology

There are 17 weapon system specific symbols presented on CPG or pilot selected display units (DA, 1984a).

(14) Fault Detection/Location System (FD/LS)

The FD/LS is contained within the fire control computer program and has two operational modes; continuous monitor and selectable monitor. The continuous monitor mode functions whenever power is applied to the FCC. The function of the FD/LS is to detect faults in the subsystems monitored and announce the GO/NO-GO conditions to the flight crew or fire control computer repairman. The FD/LS identifies the NO-GO component and its location within the helicopter. This information is presented on any of the visual display units in the helicopter and the numerous Warning/Caution lights/switches in both crew compartments (DA, 1984d; USAAVNC, 1985w).

The Data Entry Keyboard is utilized to access the FD/LS functions for certain on-command tests. There are certain tests that do require some interaction between the initiator and the fire control system. Interaction may require either switch actuation or evaluating a specific parameter or function and the decision regarding its acceptance. These command-initiated tests are displayed as a menu of 19 specific tests (DA, 1984d; USAAVNC, 1985w).

<u>o. Armament</u>

(1) M-230E1, 30 mm, Area Weapon System

This is a single barrel, externally powered, chain drive weapon using M788/789 or ADEN/DEFA type ammunition. The 30 mm gun is mounted in an hydraulically driven turret capable of slewing the gun 10 degrees left or right of the helicopter centerline and up 11 degrees to 60 degrees down. The rate of fire is set for 600 to 650 rounds per minute. Individual round cost is approximately $30. The maximum capacity of the linkless storage system is 1200 rounds. The gun duty cycle is as follows: six 50-round bursts with five seconds between bursts followed by a 10 minute cooling period (DA, 1984d; USAAVNC, 1985z; Utley, 1985).

(2) 2.75 Inch Aerial Rocket Control System (ARCS)

The ARCS is a light anti-personnel assault weapon. The ARCS consists of a rocket control panel located in the pilot's station and four station directors located in each of the four wing station pylons. The ARCS permits the pilot to select the desired type of 2.75 inch folding fin aerial rocket (FFAR) warhead, fuze, quantity and range. The M-261 lightweight, 19-tube launchers can be mounted on any of the four wing stations. There are three modes of firing rockets: pilot; CPG; and, cooperative (precision) mode (DA, 1984d; USAAVNC, 1985aa).

(3) Point Target Weapons System

The point target weapons system, commonly called "Hellfire", is the primary armament on the helicopter for the destruction of tanks and other hard targets. It provides the capability of firing missiles on the ground and airborne, at speeds from hover to the maximum flight speed. The Hellfire currently has the tri-service type laser seeker. This gives the flight crew the capability of two types of launches: lock-on-before-launch (LOBL) and lock-on-after-launch (LOAL). The type only depends on when the laser designator is fired, before or after launch of the missile. The missiles can be launched in two types of modes: normal, sometimes referred to as rapid (during which only priority channel missiles can be fired), and ripple (during which priority channel missiles can be fired alternately). Maximum or minimum engagement ranges and similar parameters are classified (DA, 1984d; USAAVNC, 1985c).

MISSION

The attack helicopter's mission is to destroy enemy armor, mechanized and other forces, employing fire and maneuver, as an integrated member of a combined arms team. The attack helicopter company or battalion employs fire and movement in the attack to dominate, neutralize, or destroy enemy forces. The mobility and aerial firepower provided by attack helicopter units allow disruption of enemy rear areas and destruction of follow-on forces and air defense systems (DA, 1984a,1984c, 1984d).

HISTORY OF SYSTEM ACQUISITION

Historical documentation of the AH-64 Apache advanced Attack Helicopter was not readily available. The original Required Operational Capability (ROC) document for the Advanced Attack Helicopter (AAH) was dated sometime in 1963 The original Mission Essential Needs Statement (MENS) (no date available) indicated a need for day and night nap-of-the-earth flight capability, essential area Kevlar armor and a capability of tolerating a "G" range of from +3.5G to *** (Personal communication, Dr. Robert Wright, ARI Field Unit, Ft. Rucker, AL, 17 July 1985).

The Army began the Advanced Attack Helicopter Program in the early 1970's as a follow-on to the Cheyenne AAH program. The Cheyenne system was a first

prototype effort which failed due to rotor design and human-factors problems (Personal communication, Dr. Robert Wright, ARI Field Unit, Fort Rucker, AL 17 July 1985). An airframe prototype flyoff was conducted in December, 1976, between the Hughes Helicopter YAH-64 and Bell Helicopter's YAH-63. Having won the flyoff competition, the YAH-64 was developed to its present state of sophistication (Breen, 1985).

PERSONNEL AND KEY JOB TASKS

1. Operators

Pilot and Co-pilot/Gunner positions on this helicopter are manned by individuals qualified to operate from either seat. An officer may fly one mission as a pilot and the next as co-pilot gunner. However, it is anticipated that pilot and CPG will usually remain together in their assigned positions aboard the aircraft. Key job tasks are principally identified as flight tasks and weapons delivery tasks. The pilot is responsible for operating the helicopter, and the CPG is responsible for operating the weapons systems aboard the helicopter. Mention was made of a possible future change such that the CPG will only receive minimal flight training sufficient to land the aircraft in an emergency.

Course length is 14 weeks and 1 day. Students are selected from previously qualified AH-1 Cobra pilots. Therefore, these students are already highly skilled in attack helicopter tactics. Once selected for training, these students attend a 24-hour training/screening program involving use of the Pilot Night Vision System (PNVS) and the Helmet display Unit in a surrogate Apache (a Cobra helicopter with a hooded, PNVS/HDU equipped rear seat). The Helmet Display Unit is mounted on the right side of the crew helmet and thus requires operators to be right-eye-dominant in order to quickly switch focus from close projected imagery to distant real world imagery. Early research by the US Army Aviation Board indicated a problem with left eye dominant individuals experiencing greater difficulty and requiring increased instruction time with the right eye HDU. These individuals never reached the skill level of their right-eye-dominant peers. Dyer (1985) has estimated that for every 10 pilot students entered into the Apache course, 2 will fail this initial screening due to an inability to adjust to the PNVS/HDU system. No research is being done to isolate the specific reasons for this inability to adapt (Dyer, 1985).

The course Program of Instruction (POI) requires 80 hours of actual flight time (37% of POI hands-on training) and 110 hours of flight simulator training (63% of POI hands-on training). An estimated 380 - 400 annual student throughput is expected. The 1986-87 timeframe was mentioned for the conversion to single -seat qualification, e.g. - separate training for pilot and CPG (Utley, 1985; Dyer, 1985). Table A-1 shows Apache oprator MOSs and courses.

2. Maintainers

Maintenance tasks are divided into two levels. Aviation Unit Maintenance (AVUM) tasks are principally based on the helicopter Fault Location/Detection System (FD/LS) capability of detecting, locating and identifying faulty

Table A-1

Apache Operator MOSs

MOS	GRADE	TITLE	COURSE LENGTH
15B1L	LT/LTC	Pilot, AH-64A AAH	14 Weeks, 1 day
100K1M	CWO	Pilot, AH-64A AAH	14 Weeks, 1 day
100KE	GWO	Instructor Pilot	16 weeks, 2 days

components down to the lowest replaceable unit (LRU). These faulty LRUs are then replaced by unit maintenance personnel following procedures indicated in applicable technical manuals. The LRUs are then direct-exchanged or turned-in to the nearest Direct Support/General Support (DS/GS) Aviation Maintenance Unit providing Aviation Intermediate Maintenance (AVIM). The supporting AVIM unit is also available for AVUM tasks at the unit level when required (DA, 1985b).

Aviation Intermediate Maintenance (AVIM) tasks are to repair system components, when possible, and return them to stock for reissue. When components are not repairable, they are either discarded or sent to depot for repair. New components are ordered to maintain a required Prescribed Load List (PLL) of repair parts for supported equipment (DA, 1985b). Table A-2 shows the Apache maintainer MOSs and courses.

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

1. Displays

There ar three major system displays: the pilot's Visual Display Unit (VDU); the copilot/gunner's Optical Relay Tube (ORT); and, the Helmet Display Unit (HUD).

a. Visual Display Unit (VDU)

The VDU is located at the upper center of the pilot instrument panel. This is a mutlipurpose unit that provides the pilot with flight, navigation and targeting information. The VDU is a repeater unit that receives a selectable signal sent from the symbol generator. A turn-and-slip indicator is located below the face of the CRT. The drive signals for the turn indicator are provided to the VDU from the DASE. Also attached to the front of the display is a track-mounted red night filter which can be placed in front of the CRT. The VDU displays TADS/PNVS imagery and selected symbology. The TADS imagery is available for pilot viewing, but is normally used only by the copilot/gunner (DA, 1984d; USAAVNC, 1985e, 1985f, 1985y, 1985aa).

Table A-2

Apache Maintainer MOSs and Courses

MOS	GRADE	TITLE
35CX1	E1-6	Automatic Test Equipment Repairer
35K	E1-5	Avionics Mechanic
66R	E5-6	AH-64 Attack Helicopter Technical Inspector
67R	E1-7	AH-64 Attack Helicopter Repairer
68BX1	E1-6	Aircraft Powerplant Repairer
68DX1	E1-6	Aircraft Powertrain Repairer
68FX1	E1-6	Aircraft Electrician
68HX1	E1-6	Aircraft Pneudraulics Repairer
68JX1	E1-7	Aircraft Fire Control Repairer
68MX1	E1-5	Aircraft Weapon Systems Repairer

(Hughes Helicopters, 1984)

Note. Additional Skill Identifier of X1 indicates special training on the AH-64A Attack Helicopter (DA, 1985).

b. Optical Relay Tube

The ORT is located between the left and right vertical instrument panels in the copilot/gunner compartment. It has two viewing options: the Head-Up Display (HUD) and the Head Down Display (HDD). The HUD and HDD views come from the same CRT. The HUD is positioned much the same as the pilot's VDU. The HDD is positioned such that the CPG can lean down into the rubber eye cups which block any outside light source. The ORT is flanked by two hand controls from which a variety of actions can be taken concerning the TADS/PNVS imagery, weapon/flight symbology and weapon activity (DA, 1984d; USAAVNC, 1984c, 1985d, 1985y, 1985z, 1985aa).

c. Helmet Display Unit (HUD)

The HUD is mounted on the helmets of the pilot and copilot/gunner. It consists of a 1 inch CRT with reflective optics such that the CRT imagery (30 X 40 degree field of view) is projected onto a transparent monocle placed before the right eye of each crew member. Operator selectable TADS/PNVS imagery and weapons/flight symbology is presented on this monocle which can be viewed while still maintaining a view of the real world in a head-up mode. The operator does not have to move his head down to acquire needed information before a specific action. If the Integrated Helmet Display Sight Subsystem (IHADSS) Line-Of-Sight (LOS) is functioning, the operator may acquire a target, identify the target, lock on the target and fire a specific weapons system without ever looking down to his instrument panel to verify any action during this process.

All necessary information can be presented on the HDU (DA, 1984d; USAAVNC, 1985e, 1985y, 1985z, 1985aa).

2. Indicators

Pilot and copilot/gunner compartments contain numerous equipment-flight-and-weapon-status indicators. These indicators range from active to passive, visual and audio. Some of these indicators are available for display on the VSU, ORT and HDU.

Most equipment indicators, e.g. - oil pressure, heat fuel, etc., are colored, numbered, vertical scale indicators ranging from green for an acceptable range, yellow for caution range, to red for danger range. Communication indicators are in the form of numbers for the selected channels. Operating lights are available with brightness controls. Audio signals are also used to indicate certain operating conditions of selected equipment, e.g. - "low rotor RPM", "threat radar warning alert" and "engine out". Helicopter systems caution and warning panels are located in both compartments (DA, 1984a; USAAVNC, 1985h).

Flight indicators are usually in the form of active symbology , representative of some form of flight characteristic, e.g. - pitch and roll, artificial horizon indictor, magnetic compass and barometric altimeter (DA, 1984a; USAAVNC, 1985h).

Weapon indicators are generally displayed on the VDU, ORT and HDU, However, fire control panels in both compartments also contain LED read-outs, selector switches, knobs, lights and alpha-numeric dials (DA, 1984a).

3. Controls

The main flight controls are the cyclic stick, collective stick, foot pedals and flight system switches/dials/knobs. Weapon systems controls are knobs, buttons and selector switches located on the fire control panel, cyclic stick and collective sticks in both crew compartments and the CPG's hand controls. The Data Entry Keyboard (DEK) located on the left panel, in both compartments, contains one rotary switch for function selection and 15 labeled pushbuttons for data entry (DA, 1984d;1 USAAVNC, 1985t).

COMPUTER CAPABILITIES

The two primary computers in the Apache are the Fire Control Computer (FCC) and the digital Automatic Stabilization Equipment Computer (DASEC). The memory capacities of the computers were not available. Questioning indicated that both computers were near capacity at present and no further expansion of memory capacity is anticipated in future product improved versions. See System Components section for descriptions of the functions of these computers (DA, 1984a; Dyer, 1985).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS

The AH-64A Apache helicopter is capable of simulating a majority of required combat flight tasks while in actual flight. Flight maneuvers required in combat can be practiced in open air or restricted range space. Nap-of-the-earth (NOE), hover, bobup, etc., maneuvers have been and continue to be practiced even during administrative flights. Air-to-air combat tasks can also be practiced with some limitations. The helicopter is not able to simulate flight tasks while on a ground-based, solid platform. A rocker platform would be required to simulate helicopter reactions to flight control inputs (USAAVNC, 1985a, 1985r; Utley, 1985; Dyer, 1985).

The greatest limitation in the helicopter's ability to simulate key combat tasks is in the area of Target Acquisition/Designation or gunnery tasks. Sixty percent (60%) of the CPG's tasks require use of the laser system. The installed laser in the Target Acquisition/Designation System (TADS) has only one operational setting and this has been determined to be eye dangerous at up to a 70-kilometer distance. This precludes utilization of the laser for training and as a result, an inability to train the CPG in his gunnery tasks on the actual equipment. The helicopter is presently unable to train the majority of gunnery subtasks (Utley, 1985).

When this problem is overcome through engineering modification or attachment of a training aid, the helicopter has more than adequate controls, indicators and displays to simulate key combat gunnery tasks if embedded training were installed as an organic or strap-on system. Potential does exist for flight operations part-task training in areas such as knowledge and procedural task without providing a rocker platform.

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

1. Operator/Team

The helicopter's electrical and mechanical characteristics are more than adequate to provide very accurate measurement and feedback concerning operator and team performance (in this case, a team being the pilot and copilot/gunner). The helicopter crew is also part of another team in that it normally operates with platoon scout elements consisting of the OH-58A/C/D Kiowa scout helicopter and other AH-64A Apache helicopters (DA, 1983c).

2. Maintainer

The Fault Detection/Location System (FD/LS) provides organizational maintenance personnel with a highly sensitive and responsive training tool. This system not only provides continuous monitoring capability, but can perform numerous subsystem specific operational checks which require the maintainer to use test points, take measurements, apply parameters and make decisions with on-screen Job Performance Aids. As with most maintenance tasks, feedback comes in the form of a system meeting operational parameters (USAAVNC, 1985b, 1985w).

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

Institutional training for operators of the AH-64A Apache consists of a five phased program of instruction, ranging from ground school to actual flight in the aircraft. At present, students are obtained from previously qualified AH-1 Cobra pilots; however, it is anticipated that 50% of the future input will come from graduates of the basic flight training course conducted at Fort Rucker. There is some consideration to modifying the present Program of Instruction (POI) so that operators will follow two separate tracks - one for the pilot and another for the CPG who will be trained primarily on the TADS. Training devices utilized at the institution have been requested to be procured and located at unit level for sustainment training in the TADS functions due to an inability to use the aircraft's organic laser designation system. Unit training schedules will be fairly active with the training requirements established for the individual and collective gunnery tasks.

EXISTING/PROPOSED INSTITUTIONAL TRAINING

1. Operator Institutional Training

The institutional course of instruction for Apache operators is conducted at Fort Rucker, Alabama and is 14 weeks and 1 day in length. Present student pilots for the AH-64A Apache are obtained from the ranks of already qualified AH-1 Cobra pilots. These pilots usually have from four to eight years of flight experience and have logged many hours in attack helicopters. The Apache is expected to replace the Cobra as the Army's attack helicopter on a one-for-one ratio. Therefore, this will not create a shortfall in trained Cobra pilots. Fifty percent of the replacement pilots, however, will come from students presently enrolled in basic flight courses (Dyer, 1985; Utley, 1985). Initial training consists of a 24-hour block of training in a "surrogate" Apache trainer. This training is designed to train students on the Pilot Night Vision System (PNVS) and the Helmet Display Unit (HDU). It is also designed to eliminate those students who cannot easily adapt visually to either of these systems. The "surrogate" trainer is an AH-1 Cobra helicopter whose rear seat has been modified to include the PNVS and HDU and provided with blackout curtains. An instructor/pilot flies the front seat when in flight and with canopy hooded; the student is trained to fly the aircraft utilizing the PNVS and HUD systems during daylight hours (USAAVNC, 1984a; Dyer, 1985; Utley, 1985). Of the 190 academic hours of hands-on training in Apache flight school, 58% or 110 academic hours are spent in simulators and 42% or 80 academic hours are spent in equipment flight time (Utley, 1985).

The bulk of the training can be identified in five phases:

a. System Orientation and Flight Characteristics

During this phase, classroom instruction is presented in system characteristics and an orientation to location and function of aircraft subsystems. The same computer-driven diagrammatic, interactive, training device used in training maintainers (AH-64A Panel Trainer) is also used during this initial phase of "ground school" training. The AH-64A Panel Trainer

contains operator panels that indicate which lights and/or indicators would activate given a specific element failure in a specific aircraft subsystem (Apel, 1985).

b. Target Acquisition/Designation System Selected Task Trainer (TSTT)

The AH-64A crew member is trained in basic and advanced systems procedures with the TSTT portable training device. The TSTT replicates the copilot/gunner's station of the AH-64A, including target acquisitions and weapon and navigation systems but excluding the IHADSS. TSTT does not require a dedicated instructor. Training is based on menu-driven, full prompted scenarios. Training signers include basic and advanced with manipulation (switchology), individual systems operation and integrated systems training. Vector graphics provide sensor imagery, including terrain features, target arrays and weapon effects. The TSTT may be used by crew members to conduct refresher training and improve operational techniques (USAAVNC, 1985c; Utley, 1985).

c. Cockpit Weapons and Emergency Procedure Trainer (CWEPT)

The CWEPT provides training for AH-64A crew members in normal and emergency procedures. It replicates the crew stations of the AH-64A, to include all flight controls, target acquisition and weapon, navigation and communication systems. Visual displays are provided for all sensors, except out-the-window, with vector graphics including terrain features, threat arrays and weapon effects. Crew members may train independently or as an integrated crew with or without instructor control. Two instructor consoles are provided for input and monitoring by the instructor. The CWEPT is used to conduct initial qualification and refresher training in aircraft systems, to practice normal and emergency procedures and crew coordination and to improve operational techniques. A request has been submitted by the TSM to field seventeen CWEPTs at various worldwide locations for sustainment training (USAAVNC, 1985c; Utley, 1985).

d. Combat Mission Simulator (CMS)

The CMS provides a training capability for flight and weapons delivery, normal and emergency procedures and sensor system operating tasks required in the operational mission of the basic helicopter. The visual subsystems provide out-the-window scene and sensor imagery to each of the appropriate crew member video displays. This provides target arrays and visuals to be engaged by the various weapon systems. Simulated imagery includes FLIR, DTV and DVO. Weapon training functions are controlled from the instructor's module located behind each crew station module. The pilot and copilot/gunner can train individually or as a crew performing an integrated combat mission with all weapon systems. With the CMS, proficiency is maintained with the 30 mm, 2.75-inch aerial rocket system and Hellfire missile system. This device can reduce ammunition requirements by 240 rounds per year for the 30 mm and 60 rounds per year for the 2.75-inch rockets for each airframe. A request to field six CMSs (three in CONUS and three OCONUS) for individual refresher/sustainment training has been approved (USAAVNC, 1985c; Utley, 1985).

e. AH-64A APACHE Advanced Attack Helicopter

Training on the actual equipment is at the laser phase of flight training. All systems tasks can be fully trained with the exception of two task areas: Emergency Tasks and Target Acquisition/Designation Tasks. Training of emergency tasks on actual equipment presents hazards to personnel and equipment. Limitations on usage of the Apache laser system for training present real target acquisition/designation training problems in the aircraft. The three TAD tasks that cannot be trained on the actual equipment (see Table A-3) are those dealing with the laser system which is the heart of the TADS function (USAAVNC, 1985a, 1985c; Utley, 1985).

f. Training Capability Comparison

Table A-3 shows a comparison of the operational aircraft and institutional training devices abilities to provide required training in selected tasks areas.

The reduced ability of the AH-64A Apache to provide full training in comparison with the Combat Mission Simulator lay in the areas of Emergency Tasks and Target Acquisition/Designation Tasks.

The AH-64A Apache is only able to train 13 (23.6%) of the emergency tasks versus the CMS's availability to train 48 (87.2%) of the tasks, and the CWEPT's capability of 47 (85.4%) of the requisite tasks. This limitation is primarily a function of hazards to personnel and equipment in presenting realistic emergency situations on the aircraft. This is not a limitation by the training device since emergencies can be simulated with no hazard to personnel or equipment.

The limitation of the AH-64A Apache compared to all training devices is in Target Acquisition/Designation. This is a function of the aircraft's inability to utilize the laser in the TAD System due to eye hazards at up to a 70-kilometer range. Without a laser capability, functions such as range finding, target handoff and "Hellfire" missile firings cannot be performed (DA, 1983b, 1983c; USAAVNC, 1985c).

2. Maintainer Institutional Training

There are ten (10) Primary Military Occupational Specialties (PMOS) involved in maintenance of the various subsystems of the AH-64A Apache at the organizational and Direct Support /General Support (DS/GS) levels. Aviation Unit Maintenance (AVUM) is performed primarily by personnel holding PMOS 67R who are located in the AVUM Platoon of the Aviation Battalion's Headquarters Company. The remaining maintenance personnel are assigned to supporting DS/GS units of Division and Corps Logistics Command (USAAVNC, 1985b).

The first course for PMOS 67R personnel was conducted from 1 April through 21 June 1985 at Ft Rucker with assistance from personnel of Hughes Helicopter, Inc (Hughes Helicopter, 1984). The Individual and Collective Training Plan (ICTP) and Individual Training Plans were under revision at the time of our visit to Fort Rucker, and DOTD personnel were reluctant to release

Table A-3

Training Comparison Between Simulators and AH-64 APACHE

Task Areas	Total Tasks	TSTT	CWEPT	CMS	AH-64
PNVS tasks	3	0	3	3	3
Before Flight Tasks	22	2	20	20	22
Hovering Tasks	7	0	7	7	7
Takeoff tasks	3	0	3	3	3
Basic Flight Tasks	23	1	21	23	23
Emergency Tasks	55	1	47	48	13
Instrument Tasks	13	0	4	13	13
TADS Tasks	15	14	15	15	12
Tactical & Special Tasks	44	5	24	42	44
Mission Tasks	35	22	30	32	35
After Landing Taks	5	1	4	4	5
TOTALS	225	46 (20.4%)	178 (79.1%)	210 (93.3%)	180 (80%)

TSTT = Fully/Partially capable of training subtasks on Target Acquisition/Designation Selected Task Trainer (TSTT)

CWEPT = Fully/Partially capable of training subtasks on Cockpit Weapon and Emergency Procedure Trainer (CWEPT)

CMS = Fully/Partially capable of training subtasks on Combat Mission Simulator (CMS)

AH-64 = Fully/Partially capable of training subtasks on AH-64A Apache Advanced Attack Helicopter (AH-64)

outdated plans. Therefore, specific information as to class size, scheduling, annual throughput and academic hours are not available.

The training device used in the majority of training for maintenance personnel is the AH-64A Classroom System Trainer. This is a computer-driven, panel- organized, stand-alone maintenance trainer. It is also used for training operator familiarization with the major helicopter system and subsystems. The trainer consists of a separate processor and a stand which contains the microcomputer, disk drive and wiring connectors into which the

replaceable panels connect. The upper portion of the trainer, connected to the stand, contains a left panel, center panel and right panel.

The left panel mount (display) contains the instructor's control panel connector access panel, power control panel and a hard-wired, replaceable, system display panel. This display panel has test point, lights and painted subsystem component displays, all showing connections. It is mounted on the panel support and connected to the computer via a ribbon cable and connectors (Apel, 1985).

The center panel management is configured much the same as the left panel. This panel is a graphic representation of control panels located in both crew compartments. It is capable of showing appropriate indications when system faults are introduced into specific systems on the left panel. It is hard-wired on the reverse side and connected to the computer via a ribbon cable and connectors (Apel, 1985).

The right panel contains a reverse projection screen, behind which is a computer driven, random-access, slide projector (Apel, 1985).

The instructor can introduce faults into any installed system display panel through the use of a hand-held data entry device and the entry of a specific code. There are, at present, eight (8) replaceable subsystem panels available for the trainer. These panels present the Fuel System, Electrical System, Hydraulic System, Automatic Stabilization Equipment, Integrated Pressurized Air System, Mission Equipment, Fault Detection/Location System and the De-Ice System (Varga, 1980).

A total of 8 AH-64A Classroom Systems Trainers have been ordered. Two are presently being used in operator training and the remainder in maintenance training (Apel, 1985).

Five Aircraft Equipment Trainers (AET) have been requested. These are computer-driven, system-specific, helicopter, mock-ups. They are specifically designed to be utilized for training the remaining nine (9) DS/GS level maintenance PMOSs dedicated to Aviation Intermediate Maintenance (AVIM) of the AH-64A Apache. The five AETs will be utilized for maintenance training on the Composite Systems, Flight Controls & Power Train, Engine and Aux Power Unit and Integrated Avionics and Armament/Fire Control (including TADS/PNVS) (Varga, 1980).

EXISTING/PROPOSED UNIT TRAINING

1. Operator Unit Training

Operator training received at unit level can be considered of two types: flight and gunnery training. Sustainment flight training is normally considered accomplished when the pilot meets, or exceeds, the required monthly flight time standards. In-flight tactics training, e.g. - orchestrated and harmonized team tactics with other platoon members, air-to-air combat and ADA

radar evasion techniques, are practiced on an individual and unit level basis (DA, 1983a, 1983c, 1984b).

AH-64A Apache gunnery training consists of a three-phased program conducted at unit level. Each phase has different requirements and standards. Differing amounts of ammunition are allocated to gunnery training based upon the training Readiness Condition (REDCON) status of each unit (USAAVNC, 1985c).

a. Phase I - Individual Qualification

Live fire individual qualification firing tables will only be used during in-unit transition, upgrading or downgrading from one helicopter system to another and during the aircraft qualification course at Fort Rucker. Individual gunnery qualification can be satisfied through use of the Combat Mission Simulator in units so equipped. Ammunition requirements for live-fire individual qualification are: 240 rounds - 30 mm; 60 rounds - 2.75mm rockets; and, 1 round -Hellfire (USAAVNC< 1985c).

b. PHASE II - Crew/Team Qualification

An annual gunnery qualification and sustainment requirement exists for the AH-64A Apache pilot and CPG. It is suggested that sustainment training be conducted midway between each annual qualification. Day and night firing tables are required for qualification. Ammunition requirements are: 400 rounds - 30 mm; and, 72 rounds - 2.75mm rocket (USAAVNC, 1985c).

c. PHASE III - Team Combined Arms/Joint Air Attack Team

This phase is intended to train team platoon and company size units. It is used to measure a unit's ability to employ individuals, crews or teams as part of a combined arms force. The firing tables may be completed as part of a Field Training Exercise (FTX), Joint Training Exercise (JTX) or Joint Readiness Exercise (JRX), ARTEP, Combined Arms Live-Fire Exercise (CALFEX) or Joint Air Attack Team (JAAT) exercise. These firing tables will be fired twice annually. Each AH-64A Apache company is authorized to fire one Hellfire missile per year. Night firing at a moving target is required. This firing will be performed by an individual selected by the unit commander. Individual helicopter ammunition allocation is as follows: 360 rounds 30 mm, 44 rounds - 2.75mm rocket (USAAVNC, 1985c).

Hellfire sustainment training will be conducted in the combat mission Simulator (where available) and through use of the Hellfire Training Missile (HTM) (USAAVNC, 1985c).

No form of embedded training is available in this system for sustainment training.

2. Maintainer Unit Training

Job Performance Aids (JPA) are available to the Aviation Unit Maintenance (AVUM) and Aviation Intermediate Maintenance (AVIM) personnel through use of the Fault Detection/Location System's (FD/LS) menu capability. There are

nineteen (19) separate subsystem-specific menus available in FD/LS. Two are used by the AVUM personnel and 17 by the AVIM maintainers. AVUM unit maintainers are only authorized to replace to the lowest replaceable unit (LRU); therefore, they will not normally require the use of more sophisticated FD/LS troubleshooting routines required by AVIM personnel who are authorized to repair system component parts (Dyer, 1985).

The FD/LS is primarily a maintenance diagnostic tool; however, it does have inherent training capability. Some FD/LS routines require maintainers to interact with the subsystem, e.g. - take measurements, move switches, determine parameters, make decisions, etc. This interactive process does have inherent training ability, but it is principally designed to be a diagnostic aid (DA, 1984d; USAAVNC, 1985w).

UNIT TRAINING COSTS

Costs of providing unit training for an AH-64A Apache equipped unit are not available. However, certain costs can be extrapolated from examining the ammunition requirements for AH-64A Apache equipped heavy division attack helicopter battalion with a full complement of 54 aircraft and two pilots per aircraft (USAAVNC, 1985b). Table A-4 shows extrapolation.

Fuel consumption rate for the AH-64A Apache is 142 gallons per hour (USAAVNC, 1985c, 1985r). That is 7,668 gallons per hour (142 x 54), per battalion, for training. Assuming a training mission of 5 hours flight time utilizing all battalion Apache assets leads to a total fuel consumption of 38,340 gallons of aviation gas (JP-4). This is a fuel consumption cost of $31,055 (38,340 x $.81) for just the AH-64A Apache. This does not include the cost of flying other aviation battalion assets, e.g. - the OH-58 Scout Helicopter and the UH-1 Utility Helicopter.

Table A-4

Training Ammunition Cost Analysis

Ammunition Type	Unit Cost	Phase I	Phase II	Phase III	Total Cost
30 mm rounds (TP)	13.60	$ 352,512	$ 587,520	$ 528,768	$1,468,800
2.75 (HE)	199.00	1,289,520	1,547,424	945,648	3,782,592
Hellfire	42,700	4,611,600	0	128,000	4,739,600
	TOTALS	6,253,632	2,134,944	1,602,416	9,990,992

Note. Personal conversation, MS Phillips, Ammunition clerk, Ft. Rucker, AL, DPT-RTD-Programs, 17 October, 1985.

SHIFT FROM TRAINING TO OPERATIONAL MODES

Not applicable since the AH-64A Apache has no embedded training.

TRAINING MANAGEMENT

The aviation battalion S-3 has overall responsibility for the battalion's training readiness. He is responsible for scheduling training requirements for the entire battalion. The individual company commanders are responsible for unit training. The program of training management at unit level does not differ in general from the training management required in any other Army unit. Training requirements are known and resources are allocated to satisfy the requirements. These are generally in the areas of flight and gunnery requirements in Phase I, II and III training. Records on individual performance are maintained at unit level and each pilot maintains his own flight log book (DA, 1984a; USAAVNC, 1985c).

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

When not being occupied with scheduled/unscheduled maintenance and operational requirements, the equipment should be available for training. Each AH-64 Apache platoon is authorized six helicopters; however, only five helicopters are required for unit tactical functions. One helicopter is available as a filler in each platoon, or three per company, i.e. - one aircraft is having maintenance performed while the other five are mission dedicated.

Maintainers are usually considered to be involved in on the job training when they are performing their assigned maintenance functions.

ADEQUACY OF TRAINING SYSTEM

If the Combat Mission Simulator (CMS) or the Cockpit Weapon/Emergency Procedure Trainer (CWEPT) is available within an easy commuting distance of operational units, the unit training system should be quite adequate for sustainment training of individual and crew tasks. Training in use of the TADS during combined arms exercises is extremely limited due to the present inability of the system to use the laser function on the aircraft. This operational training deficiency manifests itself primarily in the areas of target handoff, range-finding, artillery fire adjustment and target designation functions in team scenarios (USAAVNC, 1985a; Utley, 1985).

IMPEDIMENTS TO TRAINING

There are two main impediments to training on the operational system: the inability to practice emergency tasks and the inability to utilize the laser function in the Target Acquisition/Designation System (TADS) (USAAVNC, 1985a). Use of the CMS and CWEPT training devices, at unit level, would contribute

greatly to overcoming the present training impediments. However, if these devices are not readily available for unit training, operational readiness of attack helicopter units will be decreased.

Two potential training modifications are suggested to overcome these deficiencies. For emergency tasks, an embedded training program could be installed in the Fire Control Computer or the DASE Computer to exercise the switch functions required for a variety of emergency situations in the helicopter. An extensive bus as well as a redundant bus are available to route inputs and outputs required for such an ET system. Feedback could be provided on-screen through the pilot's VDU and/or CPG's ORT.

To allow training with the TADS Laser an engineering modification could reduce the present power of the TADS laser, or a low power laser could be installed. Neither of these ideas is new to the training developers involved with the system.

SUMMARY

The AH-64A Apache Advanced Attack Helicopter (AAH) is a highly developed rotary aircraft/weapons platform, capable of day or night operations. It contains a sophisticated array of sensor devices allowing close-in or stand-off target acquisition during day or night visibility conditions. The AH-64A Apache also contains a laser designator system allowing utilization of "smart munitions" with target hand-off or acquisition capability from other laser designators on the ground or in the air. The laser designator also has range-finding capabilities which can be utilized in fire control for the other on-board weapon systems.

A two-man crew is utilized in this aircraft: pilot and copilot/gunner (CPG). Although able to perform each other's tasks to some degree while in flight, each is concerned with specific functions of his position in the aircraft. The pilot's primary mission is to fly the aircraft, while the CPG's mission is to acquire and engage enemy targets. While unit sustainment training requirements for AH-64A Apache equipped units is extensive, training simulators have been requested that will provide a majority of the sustainment gunnery training tasks.

The operational aircraft is not capable at this time of providing training in two specific areas: Target Acquisition/Designation System (TADS) tasks and emergency procedure tasks. These tasks can be sustained on the unit training devices if available. However, TADS tasks cannot be sustained for collective training tasks, e.g. - target hand-off.

Projected training system deficiencies are noted and recommendations made for solution.

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APPENDIX B

BRADLEY INFANTRY FIGHTING VEHICLE

CONTENTS

CONTENTS (continued)

APPENDIX B

BRADLEY INFANTRY FIGHTING VEHICLE

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Fighting Vehicle - Squad Carrier and Weapons Platform for Infantry.

2. System Components and Functions:

The Bradley Infantry Fighting Vehicle (BIFV) provides weapons and mobility capabilities far exceeding the M113 armored personnel carrier (APC) it replaces. The Bradley is a major improvement in potential infantry effectiveness, but its newness has led to problems for both institutional training (Fort Benning) and unit training for transition and sustainment. This includes training in tactical doctrine, the new direct fire weapons and turret operations and maintenance.

In addition to the normal Squad's individual and crew served weapons, the Bradley carries two major weapons and two relatively lesser systems. The major weapons are the 25 mm chain gun, designed to defeat lightly armored vehicles and provide destructive and suppressive fire out to 3000 meters, and the TOW (the Tube-launched, Optically-tracked, Wire-guided heavy anti-armor weapon), designed to defeat main battle tanks out to 3750 meters.

The auxiliary weapons are the 7.62 mm machine gun mounted coaxially with the 25 mm, and the six 5.56 mm (modified M16 rifles) firing port weapons operated by squad members in the rear compartment. The 25 mm, the TOW and the Coaxially mounted Machine Gun (COAX) are normally operated by the Gunner who shares the two-man turret with the Bradley Commander.

MISSION

The Bradley was designed to fulfill the infantry fighting mission as dictated by Army 21. This requires a highly flexible defense and attack, as dictated by the situation, using the terrain for maximum cover and concealment. The BIFV was thus designed to make maximum use of the terrain in providing overwatch and establishing defensive positions.

In the Bradley, the US has adopted the chain gun and included the TOW as a permanent part of the vehicle. This allows the BIFV both roles: tank killer in the defense and support/mobility in either offense or defense. The vehicle's height allows clearing many obstacles and the 25 mm or the TOW can be fired from hull defilade on the rear side of a hill. The dismount element is able to work in conjunction with the vehicle commander in the turret in providing support for the attack, while long range anti-tank and anti-IFV fires can be provided on the defense. Similarly, the dismount element is available for MOUT (Military Operations in Urbanized Terrain) and forest environments,

and providing local security. At this time, the Bradley is the most advanced and most powerfully armed IFV in the world.

HISTORY OF SYSTEM ACQUISITION

The BIFV has been under development since the mid 1960s. Its forerunner, the MICV (Mechanized Infantry Combat Vehicle), was developed through DT and OT II by 1976, when decisions were made to modify the vehicle to include the two-man turret and the on-board TOW system. This resulted in the redesigned BIFV (and its sister system the Cavalry Fighting Vehicle [BCFV] - identical except for minor interior modifications and the removal of the firing port weapons). These became operational in early 1983.

Two modifications are currently being undertaken for the Bradley. These are the M2/3A1 and the M2/3A2 modifications. The M2/3A1 is to be a production modification starting in May 86 which includes the following:

<u>For both M2 and M3:</u>	<u>For the CFV Only:</u>	<u>For the IFV Only:</u>
Gas particulate system	Cargo hatch vision	Dragon night sight
Hatch interlock	Observer seating	Saw/M16
Turret drive indicators	Revised stowage	Mines/Flares
Driver station padding	Missiles and	2-5 Gal cans
Stowage strapping	2-5 Gal cans	on right side
New rations	on left side	
M15A2 to M256 Kits		
Two camouflage nets		

The M2/3A2 modification is in RDTE now but not yet approved for production. This proposed modification consists of:

Improved 25 mm Gun/Ammo (the long rod penetrator round is now available)
Improved Armor Protection (to meet 30 MM threat on a 60 deg arc)
Enhanced Survivability (Improved smoke, ammo stow, fragmentation protection)
Hybrid Bio-Chem Protection
Improved Crew Vision (Driver thermal viewer, Obscurant removal, etc.)
Air Transportability (Improved: armor removal; ISU removal, etc.)
Drive train, Suspension (Maintain current Mobility and RAM-D)

No major training implications are anticipated as a function of these modifications. Necessary training modifications will be implemented in USAIC and field training as mods reach the field.

PERSONNEL AND KEY JOB TASKS

BIFV squad members are usually thought of as two teams: the vehicle team and the dismount team. The vehicle team consists of the Bradley Commander, or BC, (who may be a squad leader, a Platoon Leader or a higher element

commander), the Gunner and the Driver. The dismount team normally consists of the Assistant Squad leader and six other squad members: Dragon Gunner, M60 MG Gunner, Grenadiers and Riflemen. It is currently unusual to find full squads in operational units because of personnel shortages: more typically, BIFV squads consist of from 6 to 8 total troops instead of the stated 10 personnel. In the BIFV Squad, all members carry the MOS of 11M (for mechanized Infantry). Positions and major tasks are listed in Table B-1.

Table B-1

Positions and major tasks in the BIFV.

Position	Rank	MOS	MAJOR TASKS
Commander	E5	11M30	Command and control of vehicle and squad in both mounted and dismounted opertations. Acquisition of targets and handoff and fire commands to Gunner.
Gunner	E4	11M20	Assists Commander in C&C, target acquisition, etc. Operates all major weapon systems on command.
Driver	E2-3	11M10	Drives vehicle on command. Assists BC and Gunner in observation and acquisition of potential targets.
Asst. Sqd Ldr	E4	11M20	Assists BC/Squad Leader in conduct of all duties. Serves as leader of dismount team unless Squad Leader dismounts, then serves as BC in BIFV.
Sqd. Members	E2-3	11M10	Perform duties in and out of BIFV as commanded by Squad Leader. Some serve as firing port weapon operators.

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

The major interfaces for the BIFV are those of the BC, the Gunner and the Driver. The BC and Gunner are located in the two-man turret and operate the turret and weapon control systems through use of the controls, switches, indicators and displays provided. The major visual interfaces for these personnel are direct or periscopic views and the images from the ISU (Integrated Sight Unit), which provides 4 and 12 power magnification in both

daylight (optical) and thermal modes. The ISU provides the capability for detecting and acquiring potential targets day and night. It also allows the Gunner (or Commander) to range targets and then engage them with either the 25 mm (with either HE [high explosive] or APDS [armor piercing discarding sabot] ammunition) or the TOW (Tube-launched, Optically-tracked, Wire-guided heavy antiarmor weapon).

There is no computer interface in the Bradley system and there are no displays which could be used currently for input of instructional materials. However, the ISU does provide a possible means of inputting real or simulated information to the Gunner or Commander for training. Strap-on provisions for such input are possible (as is currently done with the SAAB BT41 and some other training devices [see below]).

COMPUTER CAPABILITIES

As indicated, computer capabilities are non-existent.

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

The actual Bradley equipment can be used to simulate many of the combat tasks of the Infantry squad through use in exercise scenarios. There is no current capability to simulate many of the target recognition, acquisition, etc., tasks critical to gunnery training. Strap-on simulation capability might be added to the ISU for simulation of targets and other tactical situations for the Bradley Commander and Gunner.

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTATINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

The M2/3 system provides reasonably accurate feedback on operator and team performance during operations; however, the degree of feedback for Commander and Gunner tasks provided in training is minimal without strap-on devices of some sort (e.g. - MILES, etc.). In general, feedback is in the form of visual observation of the effects of some action, as driving, directing track movement, tracking a target, etc.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

Bradley specific training at Fort Benning consists almost entirely of hardware system training, with little training in either individual, squad or unit tactical employment of the BIFV. The primary emphasis is on learning to operate the BIFV, itself, and the weapons systems it carries. Tactical training is provided to a limited extent in the Commanders Course and related training is provided in IOBC, IOAC, PNCOC and ANCOC. The major part of all institutional training beyond initial training is on gunnery with heavy concentration on effective use of the 25 mm gun.

1. Bradley Initial Training

Initial training in the Bradley 11M MOS is given as a three week extension to the OSUT (One Station Unit Training) for the basic Infantry (11B) at Fort Benning. This training is directed toward basic familiarization with the Bradley, its required PMCS (Preventive Maintenance Checks and Services) and with driving the vehicle. Most training is on driving the vehicle and PMCS. Soldiers completing this add-on are qualified as 11M10 and are then (usually) assigned to Bradley equipped units in CONUS or USAREUR. The 11M10 training is not intended to fully train the troops on the Bradley - it is a familiarization course only.

2. Bradley Gunnery Training

The current philosophy, doctrine and guidance for all training for Bradley gunnery is presented in Department of the Army (DA) Field Manual FM 23-1 (Test): Bradley Fighting Vehicle Gunnery, (1983), hereafter referred to as FM 23-1. This manual is being revised currently to reflect changes in doctrine, techniques of engagement, etc., and the training approaches which have been evolving at the USAIS over the past years. The FM presents "a concise and effective program for gunnery training" (FM 23-1, p. ii). As such, the manual collects materials from many other sources and brings them together as a single source reference. Although originally intended primarily to serve Bradley-equipped units, the FM is widely used to support institutional training as well. The training recommendations are for use by leaders, staff personnel and training personnel at all levels. The manual is directed toward training for both the Infantry (BIFV) and Cavalry (BCFV) Fighting Vehicle teams and crews.

The manual contains three major parts: Introduction and Threat; Principles of Bradley Fighting Vehicle Gunnery; and, Gunnery Training. The introduction consists of a one-page discussion of the philosophy of BIFV employment and brief statements of the purpose and scope of the manual. It also contains 54 pages on the Threat which USAIS indicates is to be reduced or eliminated in the next edition of the FM, because of duplication of other materials available to students. Overall, the principles of BIFV gunnery are well presented and provide a good basis for unit sustainment/refresher or transitional/cross training. Transitional (training M113 personnel in Bradleys) or cross training (training other squad members to perform gunner duties) would undoubtedly require additional materials and knowledgeable instructors, but this manual provides the base for such instruction.

Part Three defines a unit training program and how to carry it out. This includes a detailed presentation of the Bradley Gunnery Skills Test (the BGST--designed to evaluate squad/crew performance of 15 tasks). It also recommends an annual BIFV gunnery training program for units (Chapter 14) and describes the elements and the exercises required in the unit to fulfill this suggested program (Chapters 15 - 19).

a. Bradley Fighting Vehicle Gunnery Skills Test (BGST)

The BGST is viewed as an important part of training in both the institutional and unit settings. It provides an evaluation of gunnery training throughout the cycle. It is administered to all course students at Fort Benning, and is used as a semiannual test of all 11M members of the BIFV (M2) squad and all M3 crew members. The tasks and squad members to be evaluated in the test are listed in Table B-2. Testing procedures and guidance on scoring and evaluating each task performance are presented in the manual. Course students and all Bradley squad or scout crews must pass the BGST prior to entry into training with either sub-caliber or full caliber firing tables. Although this test is the latest version available, USAIS has indicated that the whole chapter dealing with this test is to be revised in the near future. Information on specific revisions to be made was not available at time of reporting.

b. Bradley Fighting Vehicle Gunnery Program

A progressive gunnery training program for M2/M3 teams/crews is defined with specific requirements for each exercise portion of the overall program. It consists of training and evaluation exercises based on a yearly training cycle. It includes two qualification periods plus the ARTEP exercise annually.

The program is designed to train and evaluate Bradley team/crew proficiency in all recommended gunnery techniques under all field conditions, including varying weather and visibility conditions. Exercises are intended to be as realistic as possible, but actual exercise design and conduct is left in part to the individual unit, based on recognition of variations in local training conditions, time constraints, range availability and local training area (LTA) restrictions. Range firing and exercises must be continued during periods of reduced visibility caused by various weather conditions and that night training must be a part of the program. The firing exercises "are intended to qualify a Bradley-equipped platoon/section on gunnery skills against realistically depicted targets. . . (and) . . . to maximize the Bradley weapon systems' effectiveness" (FM 23-1, p 14-1).

The program includes:

Preliminary Gunnery Training. The program provides training in manipulation, target acquisition, range determination, thermal sight employment, dry fire gunnery exercises and squad drills for all areas of preliminary training. The five dry fire exercises for squad/crew training involve manipulation of turret weapons, with and without turret power, vehicle movement and stabilization.

Sub-caliber Gunnery Exercises. Exercises are based on the Reavis-Payne-Brewster device and either the M55 Laser or the M16 adapter (with either the .22 cal or 5.56 mm ammunition). Sub-caliber exercises are recommended with both the Stout board (Laser) with scaled targets and on scaled ranges (.22 cal or 5.56 mm). Five separate sub-caliber or Laser exercises include day and night exercises against both stationary and moving targets.

Table B-2

Bradley Gunnery Skills Test Tasks

Skills Test Tasks	Squad Members	Bradley Cdr/Gunner
Vehicle Recognition	X	X
Load 25 mm ready boxes	X	X
Apply immediate action to 25 mm Gun		X
Load Coax machine gun		X
Apply immediate action to Coax MG		X
Load TOW system	X	X
Perform misfire procedures on TOW	X	X
Remove a misfired TOW missile	X	X
Load smoke grenade launchers	X	X
Perform misfire procedures on the M257 smoke grenade launcher	X	X
Boresight 25 mm automatic gun		X
Boresight Coax MG		X
Boresight TOW launcher		X
Prepare a range card		X
Acquire/track targets with turret weapons		X

Note. Reproduced from p. 13-2 of Department of the Army Field Manual, FM 23-1 (Test): Bradley Fighting Vehicle Gunnery, December 1983.

Bradley Gunnery - Individual, M2 and M3. The FM provides guidance for individual, squad/crew and platoon/section gunnery training, also. The conduct and scoring is given for the Vehicle Team Combat Exercise (VTCE), Squad Firing Port Weapon Exercise (SFPWE), Squad Combat Qualification Exercise (SCQE), Scout Squad Qualification Exercise (SSQE), Infantry Platoon Evaluation Exercise

(IPEE) and the Scout Section Qualification Exercise (SSQE). All exercises require both day and night repetitions under existing weather conditions.

In summary, this manual is highly appropriate for unit use, but some sections (e.g. - target acquisition and identification, range determination and target engagement) are rather brief. The resulting training information is probably insufficient for producing fully adequate unit gunnery training in these areas. A new edition is anticipated in January of 1986.

EXISTING/PROPOSED INSTITUTIONAL TRAINING

1. Programs of Instruction

Major weapons gunnery training is presented in the BIFV Gunners Course, the BIFV Commanders Course and the BIFV Master Gunners Course. The BIFV Gunners Course (4 weeks) provides training for junior Non-Commissioned Officers (NCOs or E4s, E5s, & E6s) in technical (e.g. maintenance) aspects of the weapons systems, familiarization in firing the weapons and tasks related to operation and maintenance of the BIFV. The Commanders Course (6 weeks) provides gunnery training nearly identical to that of the Gunners Course, but it also gives NCOs (E6s & E7s) and Officers (O2s & O3s) instruction in command and tactical employment of the BIFV.

The BIFV Master Gunners Course (12 weeks - taught by other instructors) includes the same basic gunnery training received in the Gunners Course. It also provides more intensive weapons maintenance training, additional gunnery training, training on how to set up ranges and training on movement of BIFVs by rail, sea and air.

BIFV gunnery for the 25 mm, the TOW and the 7.62 Coaxial machine gun is taught in all three BIFV courses. Content of gunnery training such as preliminary gunnery, target engagement and live fire aspects of gunnery is very similar for all of these courses. Differences exist in the number of hours allocated to particular training segments with the most substantial appearing in the exercises. A heavy preponderance of BIFV training is both hands-on and equipment- and performance-oriented.

2. Manuals

The major training manuals to support these classes are the DA Field Manual FM 23-1 (Test): Bradley Fighting Vehicle Gunnery; DA Technical Manual 9-2350-252-10-1: Fighting Vehicle, Infantry, M2 and Fighting Vehicle, Cavalry, M3, Hull; and DA Technical Manual 9-2350-252-10-2: Fighting Vehicle, Infantry, M2 and Fighting Vehicle, Cavalry, M3, turret. These manuals provide detailed information on the actual vehicle configuration, weapons and weapons control equipment and operation and maintenance of the BIFV. Two special texts are also available for training and are used in some class preparation, etc.. These are DA Special Texts ST 7-7-1, the Mechanized Infantry Platoon and Squad, and ST 17-99, Mounted Night Operations. Also used to support training is the Trainer's Guide for MOS11M, Fighting Vehicle Infantryman, DA Field Manual FM 7-11M/TG.

Precision gunnery information is provided in FM 23-1 and during classroom instruction. Information on BIFV tactics is provided by available field manuals and training texts (DA Field Manual 7-7J: The Mechanized Infantry Platoon and Squad, DA Field Manual FM 7-20: The Infantry Battalion, DA Training Text 71-1J: Mechanized Infantry Company Team and DA Training Text 71-2J: The Mechanized Infantry Battalion Task Force).

3. Summary of Institutional Training

a. Emphasis on Night Operations and Limited Visibility Training:

Operations at night or in limited visibility increase the difficulty of successfully performing many normal daytime tasks. Techniques for night gunnery have become a critical component of training. Unfortunately, there appears to be little effort to integrate actual gunnery training into formal night training, most of which takes place in the FTX or other field exercise setting and does not normally involve ranges where actual gunnery can be practiced.

Guidelines are not currently given for optimizing detection versus identification of targets by varying display adjustments. Similarly, construction of range cards to define sectors of fire and likely locations for target appearance assumes added significance during night operations. Unfortunately, formal instruction does not stress the usual methods of accurately determining ranges for construction of the cards (i.e. walking off the distance, use of the WORM formula with the range card, etc.), nor do they emphasize placement of stakes and markers for firing positions.

b. Uses of Simulation/Substitution/Miniaturization:

One use of simulation is for 25 mm gunnery. Training includes the use of the coax as a sub-caliber substitute. A second simulator recently introduced is the Reavis-Brewster device. Scaled targets readily available in the Army training aid inventory are used with either of these applications. A second use of miniature targets is in range determination where models of Soviet vehicles are used in conjunction with the WORM formula. Currently, there appears to be little perceived need for increased availability and use of additional types of training aids/devices in the courses.

Several prototype simulation devices are currently being evaluated by the USAIS. It is expected that upon completion of those evaluations, the devices ultimately selected would be integrated into the appropriate phases of training.

4. Real and Potential BIFV Training Devices

A variety of training devices has been developed, proposed or planned for potential training of Bradley Fighting Vehicle gunnery tasks described earlier. The currently available training devices and aids for the BIFV fall into logical categories derived from device characteristics. They include add on

interactive Laser systems; AET strap-on devices; and, Simulators or Procedures Trainers. The most useful and most likely to be used are described below.

a. Interactive Laser Systems

MILES, or the Multiple Integrated Laser Engagement System, is now becoming available for the Bradley. It has been demonstrated at Fort Benning and introduced to the Bradley units at Fort Hood. This Laser training system assists training of gunnery skills by using actual equipment and actual vehicles but firing a Laser beam as opposed to a projectile. The soldiers and vehicles are equipped with sensors which detect lasing from other weapons systems. Vehicles are killed only when engaged with a Laser beam coded to represent a weapon which would actually kill the target (e.g. - a TOW Laser beam would kill an M1 Tank; the beam from an M60 MG device would not). Kills are indicated by a flashing light on vehicles and a loud continuous buzzer on individual soldiers. The MILES weapons simulators for killed vehicles or soldiers are deactivated also; they will not fire again until reset by Controllers. Recent improvements in MILES now allow better simulation of indirect fire and the inclusion of Air-to-Ground and Ground-to-Air engagements (MILES-AGES). Another recent innovation is the Laser Target Identification Device (LTID) which provides Laser sensing and control of the IRETS and ARETS targets, allowing them to be killed by the MILES system elements. This innovation allows MILES to be fired at stationary or moving targets on standard ranges. Bradleys with MILES and the LTIDs on targets at Ruth Range at Fort Benning could perform the Squad Combat Exercise without firing one round of live ammo. The system assists gunners, commanders and referees in determining who killed whom on exercises such as ARTEPS without anyone actually being fired upon and killed. The MILES system does not account for ranging to the target or the elevation required by projectile trajectory, nor does it allow for leads necessary for adequate training against moving targets. Assessment and feedback possibilities include hits, near-misses and kills for each element (soldier or Bradley), time and location where killed, identification of the opposing (or friendly) element which fired, and the effectiveness of tactical operations of the unit as a function of who was killed, when, where and why. MILES is in heavy use at the National Training Center as the major assessment tool for force on force engagements between battalions-in-training and the resident OPFOR (opposing force). Further, NETT training is now being conducted on the recently developed elements, such as the Bradley equipment and the MILES-AGES subsystem.

The SAAB BT-41 is also an interactive Laser engagement system with many characteristics similar to those of MILES. It provides in-the-optics simulation of gunfire and trajectory of rounds fired by a vehicle, which MILES does not do. Like MILES, the BT-41 uses Laser sensors on the targets (actual or simulated). The SAAB also accounts for the actual range to target vehicles, and considers the trajectory and elevation of rounds of different types to determine the exact location of hits and misses. The target simulator evaluates whether the shot was a hit or a miss. A hit is evaluated for effect of the round on the target, based on the angle of the target as viewed from the firing element and the vulnerability of the target (12 aspect angles for vehicles are modeled in relation to different ammunition). Kills are determined by the actual probabilities of kill for the round and the locations

of hits. Trajectory and sensitivity can be easily modified through programming. Documentation of all shots fired as well as received from enemy vehicles is provided on a paper print-out from the system's computer. Assessment measures include time-of-day shot was fired, round type, rounds hit, rounds to kill and exact distances in elevation and azimuth of each round from center of mass. This information is available in the Bradley (or other vehicle) for quick feedback to Commander and Gunner. The SAAB system provides a considerable advantage in precision over the MILES system (which was never designed to be a precision gunnery trainer; only a tactical trainer). The SAAB BT-41 can become a valuable gunnery training device which can allow realistic gunnery training in the field against a variety of friendly and unfriendly vehicles and weapons systems.

b. Strap-on Gunnery Training Devices/Aids

BGMTS (the Bradley Gunnery and Missile Training System made by Detras) is a strap-on gunnery simulator and a detection system associated with targets which are rear-projected onto a viewing screen. The system requires the actual Bradley to be positioned in front of the device and uses the Bradley turret and controls as part of the simulation process. A Laser transmitter is attached to the vehicle's turret and aligned with the main gun. The Commander and Gunner view the projected film display on the screen through their normal optics and perform normal target engagement procedures. Filmed field scenes of single or multiple enemy targets are displayed, with full variation in range and terrain being limited only by the availability of films. When the gun is laid on the target and the gun is "fired", the LOS (infared line of sight transmitter) emits an eye safe Laser beam which tracks the flight trajectory of the round and simulates an explosion at the predicted point of impact. Ranging is accommodated in the projection of the flight path, so short rounds appear to burst short and long rounds appear to go over the target. Feedback and evaluation capability are limited to that provided by the location of the simulated burst of the round in relation to the target. Vibration of the round being fired, flash of the gun, smoke and dust are not simulated. The use of missiles can be simulated as can engagements of moving targets. Thermal sight films are being planned.

The Reavis/Brewster device allows the use of either an M16 or the M55 Laser as a substitute for main gun firing. The device is mounted on the barrel of the 25 mm and is boresighted and zeroed via reticle adjustment in the ISU. Used with scaled targets (M16 with either 5.56 mm or .22 cal ammo) or the Stout Board (a bulletin board like device on which to mount small scale targets for use with the M55 Laser), this device allows the Gunner to practice the basic skills of aiming, tracking and firing. Any targets up to 1/10 scale can be used with the device except that problems are encountered with the very small (1/60) targets. Usable available scaled targets include 1/35, 1/20 and 1/10 scales. A problem occurs in using smaller scale targets. Normal ISU usage is to acquire targets with the 4 power optics and to switch to the 12 power for engagement. Switching to 12 power causes problems in viewing both the sight reticle and the target at the same time when the scaled target is physically too close to the ISU. When used with the M16, the Reavis modification of the Brewster device compensates for both the superelevation difference between HEI-T and ADPS-T and the trajectory differences between these rounds and those of the 5.56 mm and the .22 cal rounds. When the M55 Laser and the Stout Board

are used, the device can also compensate for elevation and trajectory differences. Thus, the device allows ranging to be trained with either application mode. A most recent development is an improved wiring harness (the Payne harness) for this device which is more economical, easier to install and highly reliable. This device should provide the capability to train both Precision Gunnery and Battlesight BOT with the Bradley, with a major reduction in costs for ammo, POL and ranges. With proper instruction and suitable targets, vehicle identification, firing on moving targets and range estimation might be taught as well.

Plastic ammunition can be used with either the Reavis/Brewster device (5.56 mm and perhaps .22 cal) or the coaxial machine gun. It is not yet clear whether the ranges of the small caliber plastic ammo will be satisfactory to allow scaled range usage. Plastic ammo for the 25 mm is being considered and may be made available in the future. None is currently in production. Although trajectories may be considerably altered by the use of any caliber plastic ammunition, it may prove usable in conjunction with scaled ranges and targets to train several aspects of gunnery at reduced overall costs.

c. Simulators/Procedures Trainers

The COFT (Conduct Of Fire Trainer) is being developed in Unit and Institutional models, with the initial U-COFTs having been delivered to Fort Benning in April 1985. The first I-COFT is expected to be delivered in 1987. The U-COFT provides a high fidelity simulation of the interior of the Bradley turret and allows performance of most of the procedural functions of the BIFV Commander and Gunner. It does not provide a 360 degree field of view for either the Commander or Gunner. Driver functions are not trainable in the device, but some results of the driver functions are presented to the Commander and gunner, such as the simulation of vehicle driving and stopping on orders from the commander. Computer generated imagery (CGI) visual displays are presented to the Commander and Gunner through the simulated ISU, the unity window and a single commander's periscope. Scenes presented can include day views, night views, thermal displays, fog, haze, smoke obscuration and other simulated weather conditions. The computer generated field of play is 3000 by 6000 meters and allows the insertion of multiple vehicle, aerial and troop models in the field of view. Both moving (up to six) and stationary targets can be presented and the models appear to move relatively realistically. If hostile targets are not engaged within set times, enemy fire is received. Round trajectories are depicted realistically in addition to round impact. An instructor's station allows monitoring and control of the training process and the computer automatically keeps records and scoring. The instructor can choose to use a computer-selected sequence of sessions (each about ten minutes long and presenting about ten targets), based on the performance of the crew in prior sessions, or he can at any time select specific training sessions for the crew. Sessions vary in difficulty based on target number (single or multiple), own vehicle motion or target motion and other parameters (as weather and malfunction conditions). The training sequence can be frozen by the instructor at any point in time for critique of individual task performance. An entire exercise can also be played back for instructional purposes. Performance criteria are built into the system and scoring on individual sessions is used to determine what sessions will be presented next to any given team. Scoring

and performance measurement are precise, consistent and recorded by team and by unit (when fielded). Various formats of printout summaries are available to the instructor or the Unit Commander for training management purposes. The system does train turret procedures quite well and teams trained in the U-COFT performed live fire as well as teams trained on the actual equipment during the OT-I for the U-COFT (Moon & Strasel, 1982). Some major tasks, such as 360 degree observation and vehicle identification, are not trainable in the U-COFT. Training for range determination may be questionable also, due to imagery differences. There is no attempt to simulate or to train for gun malfunctions. On the other hand, the capability for training many normal and emergency procedures (including turret power failures) in a wide variety of limited visibility conditions is a major training plus.

The Perceptonics MK-2/3, the Bradley version of the videodisc-based Part Task Gunnery Trainer (PTGT), also called the VIGS (Videodisc Interactive Gunnery Simulator), can be used in a classroom or in the field (on ranges) to simulate the Gunner's firing tasks. The trainer is a single station (Gunner only) device which presents videodisc-stored film images of actual vehicles on a TV monitor viewed through a simulated Gunner's ISU. Gunner's handles are placed in a reasonably accurate simulation of the original turret and their manipulation causes the "scope" field of view and reticles to move across the visual scene displayed on the monitor. Targets can be tracked, ranges can be determined using stadia lines and firing can be simulated, including selection of weapons and ammunition options. Firing commands are presented to the Gunner aurally. Automated scoring of hits, misses and rounds fired is built into the trainer along with certain other performance characteristics. Certain deficiencies in this trainer have been identified by USAIS SMEs (Subject Matter Experts) and communicated to Perceptronics, but not all of the fixes have yet been made. As it is now, this trainer should be useful for initial or sustainment training of some of the basic gunnery procedures. With the deficiencies fixed, it could also be useful for refresher training in ranging, IFF and night gunnery if appropriate imagery could be made available.

EXISTING/PROPOSED UNIT TRAINING

1. New Equipment Training (NET)

New Equipment Training (NET) for Bradley-equipped units was initiated in 1983 at Fort Hood, TX. Two separate NET Teams (NETT) have provided training to multiple Battalions in USAREUR and at Fort Hood by this time. Both were formed through special selection from cadre of the School and were trained in an early version of the Bradley Master Gunners course as train-the-trainer sessions.

The Fort Hood Team administered the first on-site training to the 2nd Armored Division in early 1983. Training was conducted within the normal cycles of the Division on LTAs at Fort Hood. It was controlled and sequenced to some degree by the Division requirements and the Battalion Commander. An important aspect of this NET was that the BIFV squads were trained as a unit, with all members of the squads participating to some degree throughout the training. A TCATA study reported that both maintenance and operational

training was fully satisfactory to allow BIFV units to accomplish their missions throughout the period of that study (TCATA, 1984).

The USAREUR NET Team administered their first training during fall and winter of 1983-84 to the 3rd Infantry Division. Training in USAREUR required personnel to travel to Grafenwoehr/Vilsek for maintenance and operational training, including gunnery training. Thus, unit personnel were more under the control of the NETT than had been the case at Fort Hood. Another difference between the two training situations was that the USAREUR NETT trained vehicle teams (Squad Leader, Assistant Squad Leader, Gunner and Driver) *separately from* the other squad members. Interim briefings by the TRASANA group conducting the Training Effectiveness Analysis (TEA) for BIFV indicated that the early NET training in USAREUR suffered some difficulties, especially in maintenance training (La Roque, 1984a). A problem reported was the lack of adherence to the POIs for maintenance training and the resultant underutilization of training time and trainee time. Subsequent reports indicate that these NET difficulties have been largely corrected (La Roque, 1984b).

NET gunnery training was based on the USAIS POIs for the Gunners Course and the Commanders Course. NETT personnel modified the basic content of the Benning POIs only as needed to train unit personnel at the appropriate levels. Modifications to basic concepts and POI materials were consistently cleared with the Infantry School prior to implementation. NETT personnel also used the contents of FM 23-1 as guidance for training and for input to unit trainers. All gunnery training included essentially the same exercises as presented in current courses at the Infantry School. Thus, NET training closely paralleled that currently provided at Fort Benning, but emphasis was on preparing unit personnel at all levels to perform their respective jobs and to work together as teams.

2. Unit Training Observations

Observations of tactical training exercises at the squad level at both Fort Hood and Hohenfels in USAREUR were reported elsewhere (Rollier, et al., 1984). Observations and collecton of data on unit gunnery training and training programs were a secondary objective. Although no actual unit gunnery training was observed at either location, preparations for home station pre-MTA gunnery training were observed and discussed with unit trainers in USAREUR. Trainers reported that FM 23-1 was the basis for their total gunnery training program. The unit program consists of the preliminary gunnery training and firing exercises outlined in the FM. They routinely conduct local area training on dry fire and other preliminary gunnery skills in preparation for their qualification firing at Grafenwoehr. Crew gunnery and squad drills are routinely conducted based on local and Department of the Army guidance. These are intended to prepare Bradley teams for the vehicle team, squad and platoon qualification exercises (VTCE, SCQE and IPEE).

Observations included sub-caliber firing (with a local adaptation of the Brewster device) against scaled ranges resembling GDP positions. The tank version of the B/TGMTS (Bradley/Tank Gunnery and Missile Training System, by DETRAS) was also used. Unit trainers indicated that such devices were fundamental to successful training, given their training area restrictions on

full caliber or even 7.62 mm firing, allowing more frequent practice by Bradley teams than any other available resource.

Trainers also used scaled ranges to train range determination with the choke sight in the ISU. Scaled vehicle silhouettes were mounted on movable target stakes at varied distances from the vehicle line; Commanders and Gunners then ranged on the targets at various simulated ranges. Trainers reported that this training had considerably improved initial ranging on full scale targets for some gunnery teams but no details were available.

No formal programs were available for training for thermal mode use of the ISU and thermal image identification. Trainers recognized that such training was needed but no development efforts were reported to be underway. Apparently, little emphasis has been placed on this aspect of gunnery, day or night.

The USAREUR unit trainers also indicated that the available Master Gunners (from Fort Benning training) were being used mainly as battalion level primary instructors for sustainment and transition training of individual Bradley gunnery teams.

As in USAREUR, the visit to Fort Hood was primarily to observe tactical training and evaluation during ARTEP exercises. Again, no direct gunnery training could be observed. However, discussions with Commanders and trainers were possible and some information corroborating the USAREUR data was obtained. The following similarities were found:

a) the unit also used the programs outlined in FM 23-1 as the basic building block gunnery training program. For both preliminary training and for qualification, the principles and gunnery exercises of the FM were reported to be followed closely;

b) the unit was also using team and squad drills based on the drills promulgated by the Army Training Board with local modifications (undefined) to meet their needs;

c) as in USAREUR, Master Gunners were mainly being used to train other gunners and vehicle teams (this was still true although this unit had had the Bradleys for nearly one year at the time of observation);

d) although more experienced with the Bradley and dedicated to night fighting by the 2nd Armored Division charter, this unit still had no effective training program for thermal mode ISU operation or identification of thermal targets.

The Fort Hood unit had the advantage of practicing both sub-caliber and other exercises on the major ranges and practice areas available on the post, rather than being limited to the small local area as in USAREUR. This seemed to result in less interest in training devices (although the use of the Brewster device was reported) and more concern with live fire practice whenever possible. Also, this unit had taken their qualification exercises on the tank ranges (Tables VII and VIII) at Fort Hood. At the time of data collection

there were no ranges designed for Bradley exercises at Fort Hood, although such ranges were planned for construction in FY 85-86.

3. Summary: Unit Training

These limited observations from Bradley units strongly indicate that gunnery training is highly dependent upon the doctrine and guidance promulgated by the Infantry School in FM 23-1. This heavy dependence makes it essential that this FM be updated soon to allow units to conduct better gunnery training.

With respect to current training in units, a number of problem areas were observed and reported. These include serious concerns about use of the ISU, especially the thermal viewer; night gunnery training; night training in general; and, target acquisition, recognition and engagement. Major concerns are also reported by units about the training of both Master Gunners and Bradley Officers. Similarly, the units report concerns about the total gunnery program, its progression and the various qualification requirements for different levels. There are also reports of concern about requirements for conduct of preliminary training, dry fire gunnery and sub-caliber training in home LTAs.

UNIT TRAINING COSTS

The quality of training will always be dependent on the quality and quantity of resources to support that training program. If Bradley units are supposed to go to ranges to train but have no fuel to get there, not much training takes place. Similarly, if the ranges are inadequate to meet the training objectives of the exercises, or if ammunition is in short supply and cannot support the training, then little effective training can take place.

The estimates shown below were developed by knowledgeable personnel at Fort Benning (DOTD, STRAC, BFVS-TSM, WGMD, 197th Inf Bde (Sep), and others) and staff of the Director for Army Ammunition, Ranges and Targets (DAART) at Fort Eustis, VA.

1. Ammunition Requirements for M2/M3 Training

DA Field Manual FM 23-1(Test), (1983), recommends an annual unit Gunnery Training Program for the M2 and M3. Ammunition requirements for specific M2 and M3 exercises are discussed in the same FM, chapters 17 through 19. These two sections are the basis for the present ammunition requirements as estimated by the BFVS TRADOC System Manager (BFVS-TSM) and separately by the BFVS New Equipment Training Team (NETT) from the 1/29th Infantry Regiment (Formerly WGMD). The cost per round ($37 for APDS and $22 for TPT) was provided by the Director for Army Ammunition, Ranges and Targets (DAART) at Fort Eustis, VA.

a. BFVS-TSM Estimates of Unit Training Ammunition Requirements

The BFVS-TSM prepared a set of projected ammunition requirements based in part on the gunnery training program of FM 23-1. This ammunition requirement considers the rounds needed for six of the eleven training events in the Annual

Gunnery Training Program: Vehicle Team Combat Exercise (VTCE), Squad Combat Qualification Exercise (SCQE), Scout Squad Qualification Exercise (SSQE), Scout Section Qualification Exercise (SSQE), Platoon Live Fire Exercise, Proficiency Firing Exercise and Scout Crew Combat Exercise. All of these exercises are for one day and one limited visibility run across Qualification I, Qualification II and/or ARTEP exercises. Table B-3 summarizes the rounds required and the costs. Cost information on 25 mm rounds was provided by DAART, Fort Eustis, VA, in September 1984.

Table B-3

BFVS-TSM estimates of annual ammunition costs for a Mechanized Infantry Battalion

Rounds (Costs)		
ADPS	TPT	TOTAL
44,700 ($1,653,900)	24,960 ($549,120)	69,660 ($2,203,020)

b. New Equipment Training Team (NETT) Estimates

The New Equipment Training Team (NETT) of WGMD was tasked by the 1st Cavalry Division, Fort Hood, Texas to forecast a minimum amount of M2/M3 ammunition per exercise (NETT training plus one run) consistent with the training philosphy of FM 23-1. The ammunition requirements estimated by the NETT are based on:

1) the Mechanized Infantry Battalion E/W (BFVS) TO&E J410, April 1984; and,

2) four exercises from the suggested annual gunnery training program: Vehicle Team Combat Exercise (VTCE), Squad Combat Qualification Exercise (SCQE), Scout Squad Qualification Exercise (SSQE), and Vehicle Team Sub-caliber Exercise (VTSE) for Firing Port Weapon (FPW) all for one Qualification run in both day and limited visibility modes (FPW day mode only). The NETT personnel used the actual compositon of the 1st Cavalry Division to prepare their ammunition estimates.

c. Comparison of Unit Ammunition Estimates

For comparison purposes, the NETT estimated 25 mm ammunition requirements are summarized in Table B-4. Comparison with Table B-2 shows the number of rounds and costs of ADPS is reduced 61.4%, TPT 48.9% and Total by 56.9% by the NETT proposal. While neither WGMD nor the NETT group advocates this reduction

to the absolute minimum, they believe that such a reduction would still meet the basic requirements of FM 23-1.

It is significant to note that DAART and the STRAC Directorate requested ammunition funding for FY 85 to support 66,000 APDS/TPT rounds per Mechanized Infantry Battalion, an amount close to the BFVS-TSM estimates for the current program.

Table B-4

NETT estimates of annual ammunition costs for a Mechanized Infantry Battalion

Rounds (Cost)		
APDS	TPT	TOTAL
17,240 ($637,880)	12,760 ($280,720)	30,000 ($918,600)

2. Summary of Ammunition Training Costs

This review indicates the requirements for Bradley ammunition are very heavy and the costs are very high. Even though costs have been decreasing over the last five years (from about $52 in FY 79 to about $20 in FY 84-85 for TPT), the increasing number of battalions being equipped with Bradleys will continue to push overall costs upward quickly. DAART and STRAC requested funding for 66,000 rounds per battalion for FY 85, and the USAIS DOTD STRAC Group requested 68,460 rounds per battalion. These requests were reduced by the Department of the Army.

Another question regarding ammunition has been that of actual supply. A few years ago it was predicted that there would be huge shortfalls in production to meet full requirements when the Bradley was fielded. So far no shortfalls have occurred; however, it is anticipated that such shortfalls may occur in FY 86-89, due to the increased unit demand. One other aspect of this is that some units and installations that requested large amounts of APDS cannot currently fire APDS because of range restrictions (as, for example, there is no range at Fort Benning on which APDS can be fired). USAIS has requested a 1 to 1 exchange of TPT for requested APDS for those installations where the latter cannot be used; but again DA will provide only a 70% exchange rate. This means that the projected requirements may not fully materialize until projected range construction projects have been completed. Currently installations and units must adjust their actual training schedules, exercises and ammunition usage to the limits of the range support available.

For the present, it appears that neither ammunition costs nor supply will be direct constraints to training Bradley units. However, the total costs escalation resulting from increasing Bradley unit numbers will continue to

drive the Army toward dollar and resource saving training alternatives to live fire. With more units there will be more competition for the limited ammunition dollars and fewer rounds per battalion will likely be the result. This situation makes the development of more cost effective training programs all the more important. Identification and implementation of BIFV training improvements, whether device-based or not, will become a more crucial aspect of the USAIS requirements as this trend continues.

SHIFT FROM TRAINING TO OPERATIONS MODE

This category largely applies to systems with embedded training capabilities and thus is not wholly applicable to the BIFV.

However, the BIFV does allow some strap-on training devices which do require considerable time to mount or dismount. The MILES system requires about 1 - 1 1/2 hours to mount or dismount; the BGMTS requires several hours setup time and requires the BIFV to be in a non-tactical location (motor pool or hanger area) for use. Even the sub-caliber training devices require the vehicle to be in a non-tactical environment on approved ranges. Only tactical exercises provide tactical training in a pseudo-operational environment.

If embedded training were to be developed as a strap-on to the Bradley (conceivable for inputting simulated targets, etc., to the ISU), the mount/dismount time would also be likely to be quite extensive. However, such training might readily be adapted to mounting and use in the actual tactical environment -- including on GDP positions in western Europe.

TRAINING MANAGEMENT

Training Management for BIFV is being supervised by the USAIS and particularly by the BFVS-TSM, the TRADOC System Manager's office. Doctrine and training are evolving together with interaction between the School and the field. Institutional training has been designed by the School and is now being implemented by the 1st/29th Infantry Regiment at Fort Benning.

One problem in training and training management is the role and use of the Master Gunner in units. USAIS defined the Master Gunner's major role to be that of training advisor to the battalion command staff, rather than that of direct instruction. However, both at Fort Hood and in USAREUR, the usual mode of operation is to have the Master Gunner doing direct training of other Gunners and cross training other BIFV squad personnel. This utilization of the Master Gunner skills may be somewhat appropriate in a newly equipped battalion. However, this role has yet to be concretized. Perhaps as the units become more highly experienced and receive more school trained personnel, the Master Gunner will be able to assume the more general role envisioned by the Infantry School, and similar to that implemented by the Armor community for tank Master Gunners.

Additional input on Bradley training and training management needs was obtained at the Bradley Fighting Vehicle Systems Training Conference convened at Fort Benning by the TRADOC Systems Manager (TSM) (King, 1984). The

conference was to provide field feedback on the BIFV doctrine and training provided by the Infantry School. Many issues discussed at the conference were related to the development and management of training in BIFV doctrine, tactics and techniques.

The following issues were prepared by USAIS-BFVS-TSM for the meeting:

1) What changes need to be made in FM 23-1 (Test)?
2) Can the number of rounds currently allocated in FM 23-1 be reduced and still maintain crew proficiency?
3) Gunnery qualification should be at Crew? Squad? Platoon Level?
4) Should NET gunnery be revised and standardized for both USAREUR and FORSCOM? If Yes - Standards? Exercises?
5) Is the BGST a good diagnostic tool?
6) Are present crew duties adequate?

Inputs on these and other issues were provided by the 2nd Armored Division (Fort Hood) and the 3rd Infantry Division (USAREUR). The key concerns of each unit were:

<u>2nd Armored Division Major Concerns</u>

Sustainment Training Requires:
- Annual Qualification for All Teams
- Master Gunner Certification
- Benning Validation of Master Gunner

NET Recommendations:
- Provide Tactical Overview
- Maintain the Squad Trainer
- Increase Target Acquisition - Reduce Building Block System
- Train Position Specific Personnel

Gunnery Specific:
- Qualify Three Times a Year - with Equal Priority
- Move Towards Vehicle and Squad Qualification
- Combine Tactics with Gunnery Training
- Double VTCE Requirement
- Double SCQE Requirement
- Integrate TOW Selection Training

Master Gunner Training:
- Vehicle Technical Expertise Excellent
- Increase Training for Practical Applications:
  - Range Design
  - Range Operations
  - Targetry

Officer Training:
- Include Range Design Operations and Targetry
- Certification for Bradley Officers

<u>3rd Infantry Division Major Concerns</u>

Level of Qualification
- Vehicle, Squad Qualification
- Platoon Qualification
- Requirement for Standardization of Qualifications

Concern with ARTEP and Gunnery Standards

Gunnery Tables
- Need revisions
- Better Integrate Dismount Team

Range Design
- Development of Local Training Ranges
- Training in Range Design and Operations Required

Night Fighting
- Focus on Commander and Gunner Interaction
- Need for IFF and Thermal Training for Combat and Training Applications

These concerns were raised but not widely discussed. There was little argument against these items, but there was also little consensus as to what to do about them. They do indicate the field's concern for training and training management improvement. Bradley-equipped units are experiencing many of the same problems observed in the institutional training. They are also perceiving training management problems which have been unrecognized to date.

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

Availability of soldiers and equipment for training in units will be relatively high, given that it is understood that at least one-third of all assigned soldiers will be doing non-training tasks at any given time. The usual unit training cycle in FORSCOM and USAREUR units allocates one-third of time to prime training, one third to a secondary training level (sort of targets of opportunity for training) and one third to details, ash and trash and personal or unit committments for non-training.

In Bradley units the soldier is more likely to be available for training than the equipment. Both down time of vehicles and routine maintenance will work to this end position. During prime training time or when conducting a field exercise, the unit will work with utmost determination to make every body and every vehicle available for training. This will still be only partially achieved. At other times, relatively fewer personnel and vehicles will be available for any training.

On the other hand, at any time some portion of assigned men and vehicles will be available for training. And, if training is available, the troops will always welcome it.

This question was initially asked with reference to whether the system equipment were always required to be operational or not - whether it could be made available for training when training were available. The answer is that the BIFV units do not, in peacetime, assume a fully operational posture. Therefore, at least some time is theoretically available for training, whether it be standard training, embedded training or some other format.

ADEQUACY OF TRAINING SYSTEM

In general, the Bradley training system is fairly adequate for meeting the tactical and operational needs of the system. There are some serious deficiencies in both institutional and unit training which limit the eventual effectiveness of the BIFV squad. Some of these have been referenced above under the training descriptions and under training management.

With respect to current training, major concerns are reported by units about the training of both Master Gunners and Bradley Officers. Similarly, the units report concerns about the total gunnery program, its progression and the various qualification requirements for different levels. There are also reports of concern about requirements for conduct of preliminary training, dry fire gunnery and sub-caliber training in home station training in local training areas.

It is clear that a number of problem areas exist in the current doctrine for BFVS gunnery training and in its implementation in the field. The doctrine from the School, as represented by FM 23-1, tends to be sketchy in several important areas including the following:

1) target acquisition training
2) target identification training
3) thermal mode ISU operation training
4) thermal mode target identification training
5) utilization of available identification training devices
6) range determination training
7) integration of gunnery training with tactics
8) utilization of available gunnery training devices
9) gunnery in night fighting in general

In addition to these areas of light coverage, the BGST, the basic evaluation tool for squad member proficiency, is thought to be presently inadequate and is to be revised. A total revision of FM 23-1 is to be available in early 1986.

On a somewhat more basic level, the current BIFV training provided in the School also does not fully prepare Gunners or Commanders to fight the Bradley effectively in many situations. While procedural skills and tasks appear to be adequately trained, training is slighted for the tactical aspects of gunnery and several of the most highly critical Commander and Gunner tasks. These inadequately trained tasks include:

1) site selection
2) determine fields of fire

3) 360 degree observation
4) reaction to enemy fire
5) acquire potential targets
6) target identification
7) estimate target range
8) determine target priority
9) observe and adjust fire

In particular, training in target acquisition, in Threat knowledge, in target identification, in range determination and in use of the thermal mode of the ISU are lacking in depth and breadth of coverage. The programs of the Gunners, Master Gunners and Commanders Courses are equally inadequate in training for the above tactically related aspects of gunnery. Training time previously provided for the ISU thermal mode has been eliminated from these courses. Similarly, target identification training consists of a few hours in which trainees are shown photographs of vehicles with little systematic feedback on success or failure of identifications. Other available materials for combat vehicle identification (both day and thermal) are not used nor even mentioned. Training on the Threat and the capabilities of Threat vehicles is also nearly non-existent.

Some of these training deficiencies could be improved by simple changes in POI content. Correcting other deficiencies in training may require development of training programs and materials which effectively integrate some of the developing training devices into the training programs. For example, the current deficits in range determination and estimation training might be dealt with in this way. Some of the current devices show promise for providing range estimation training if appropriate materials and training sequences could be developed. These include at least the Bradley Gunnery and Missile Training System (BGMTS) and some adaptations of scaled ranges as possibilities. There is a distinct potential, also, for using the precision gunnery capability of the SAAB BT-41 to improve range estimation based on appropriate training and feedback provided within tactical exercises, or in range exercises when combined with the Laser Target Indicator Devices (LTIDs) for range targets.

In both the School training and unit training for gunnery, night operations training was found to be nearly non-existent. Each of the formal eval tion exercises within the gunnery courses and in the unit taining program do include the requirement to perform the basic range exercise at night as well as in daytime. However, this is essentially the extent of night gunnery training that occurs. No other night gunnery training was observed in the School nor reported by unit personnel interviewed. Night tactical exercises were in fact observed in both USAREUR and Fort Hood, and in both cases Gunners and Commanders were using the ISU for both maneuver and surveillance. However, nothing which could be called gunnery training, or even practice drills, was observed in either exercise. Simulated gunnery engagements with "enemy" vehicles did occur in these exercises, but the training value of such activity, without control or feedback, must be suspect.

IMPEDIMENTS TO TRAINING

The major impediments to training in BIFV units are those which are common to every unit in the Army: turbulence in personnel; lack of experienced NCOs; training time being foregone to carry out other assignments; inexperienced training planners; and, similar items. Routine training on standard infantry skills and operations suffers because of these items. So does and will the new training required to sustain the BIFV specific skills of the Bradley Commander, Gunner and Driver.

BIFV turret team training has been hampered until recently because of the lack of availability of the U-COFT in units. Although the BIFV was initially fielded in early 1983, the U-COFT began arriving in units in June 1985. This delay has not been unusual for training devices serving major systems, but such delays in training system deliveries could be avoided if ET were implemented as a major part of the training system. ET would necessarily be delivered as part of the prime system.

SUMMARY

The Bradley Fighting Vehicle and the BIFV in particular is a new weapon system for the Infantry. It has posed new training problems for USAIS and the doctrine and training for the system are still evolving (two + years after initial fielding). There is no current embedded training in the Bradley system and the feeling resulting from this review is that there would be only limited benefits to be gained from providing such training. The training which is needed most in the Bradley is in tactical employment of the vehicle as part of a combined arms task force and in detecting, acquiring and engaging appropriate targets. Embedded training might fruitfully be employed in a strap-on mode to train the target related tasks of the Commander and Gunner. Some training in these activit'es is to be provided by the Unit Conduct of Fire trainer (U-COFT), which is now being delivered to units. Additional training can be provided in units using existing training materials if unit commanders and trainers will implement already available items.

This review of the BIFV training system has identified some training gaps or needs which should be noted. These are requirements for additional training and/or training revisions which could result in improved Bradley performance in units. Several areas of training need have been identified and are discussed below.

First and foremost, Bradley gunnery training should be intimately intertwined with the training of overall Bradley doctrine, tactics and techniques - as part of a total systems' training package. That is not currently happening either in the School or in units. Training is being done piecemeal, in insular portions, and there is little interrelation of the parts to form the whole of Bradley training that should exist. In our review and in a related document (Rollier, et al., 1984) it has been shown that there is little integration of tactics and doctrine with the fundamentals of Bradley gunnery. This does happen to some extent in the Commanders Course, but only to

a small degree. Otherwise, gunnery training is basically isolated from tactical training and is taught as an end in itself.

This piecemeal approach stems in part from a lack of an integrated Infantry School position on the role and functions of the BIFV. If the Infantry mission remains what it has traditionally been - to support armor in the offense and to take and hold ground, it needs to be clearly stated that the Bradley is only a new tool with which to perform that Infantry mission. Much current training presents the BIFV as a new and different system, requiring new and different applications. This ignores the need for BIFV capabilities to support the basic infantry mission - to support Infantry Squad, Platoon, Company and higher unit activities. There is a need to provide an integrated doctrinal basis for all Bradley training, for its implementation, and for effective employment of its weapons capabilities, in the context of the Infantry mission as required by Army 21. This conceptual approach should also be integrated into the new version of FM 23-1. This would lead to better integrated and more tactically meaningful BIFV training.

In summary, the following describe the status of institutional and unit training as observed and described by institutional and unit trainers:

1) Gunners Course:

* Provides Basic Familiarization with Bradley Gunnery
* Concentrates on Procedural and Pre-Gunnery Skills
* Procedures Basically Well Trained and Learned
* Limited Firing Restricts Expertise

* Problems:
  Inadequate Training in:
  - Range Determination
  - Target Acquisition
  - Target Identification (IFF)
  - Target Engagement - Live Fire (or Adequate Substitute with Live Targets)
  - Night Gunnery

* Produces Gunners who Need Much More Training to "Qualify"

2) Master Gunners Course:

* Gunnery Training is Essentially Identical to Basic Course
* Mechanical Procedures, Maintenance and Training are Stressed and Generally Well Done

* Problems:
  Gunnery Problems are Identical to Basic Course

3) Unit Training:

* Master Gunners in Units Share Limitations of All Course Graduates
* Master Gunners Are Attempting To Train New Gunners and Upgrade Basic Course Graduates
* Unit Gunnery Trainers Are Trying to Develop Local Training
* Devices and Aids to Training Are Being Fabricated locally

* Problems:
  FM 23-1 is Weak in Many Necessary Training Areas

  Training In Units Suffers all Usual Restrictions:
  - Incompletely Trained Instructors
  - Lack of Training Time In Adequate Facilities
  - Inadequate Training Devices, Aids and Materials
  - Overall Lack of Time for Training
  - Turnover in Personnel (Although less than Normal)

  Results in Continued Inadequate Training in:
  - Range Determination
  - Target Acquisition
  - Target Identification (IFF)
  - Target Engagement - Live Fire (or Adequate Substitute with Live Targets)
  - Night Gunnery

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APPENDIX C

PATRIOT MISSILE SYSTEM

CONTENTS

APPENDIX C

PATRIOT MISSILE SYSTEM

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Surface-to-Air Missile System

2. System Components and Functions:

The Patriot System consists of:

The Battery Fire Control Section (FCS) (currently 3 per Battalion increasing to 6 in 1988);

The Battalion Information and Coordination Central (ICC);

The Communications Relay Groups (CRGs);

The Launcher Sections (8 per battery with 4 missiles each); and,

Transportation and Maintenance elements (U. S. Army Air Defense Artillery School [USAADASCH], 1985d).

The Fire Control Section is an Engagement Control Station (ECS) that controls up to eight launching stations. The Fire Control Section also includes an electronic-scanning phased-array radar set that provides low and high-altitude surveillance,detects, identifies and tracks targets, and tracks and guides the missile. The Fire Control Section also includes an electric plant and an antenna-mast group (USAADASCH, 1985d).

The "brain" of the ECS is the weapons control computer (WCC) which controls the radar and launching stations and which also guides the missile to the target. The WCC automatically appraises target threat and selects an appropriate response. In the semi-automatic mode, operators select and engage targets that the system has detected and evaluated. Patriot can also function in an automatic mode where operator selection of targets is not needed although operators have the opportunity to veto system choices (USAADASCH, 1985d).

The battalion Information and Coordination Central (ICC) is a modified ECS that coordinates engagements of the three (eventually six) fire control sections. This command and coordination set correlates targets, resolves identity conflicts, assesses threat, and establishes engagement priorities (USAADASCH, 1985d).

Communications relay groups (CRGs) at each ECS and at the ICC allow non-line-of-sight deployment between the ICC and the ECSs. They provide both a radio-wire integration capability within the battalion and an entry and exit point for inter-battalion communications (USAADASCH, 1985d; Van Patten, 1985).

3. Prime Mover:

Patriot is 100% mobile with launcher and radar set towed by the 10-ton heavy expanded mobility tactical truck (HEMTT) with ECSs and ICC each mounted on an M-814 vehicle (Department of the Army [DA], 1984b; Infante, 1985).

MISSION

One of two major missions will be to protect deep-strike assets used to disrupt enemy follow-on echelons before they reach the main battle area. This mission will be accomplished with rear-located Patriot units. The other major mission will be to protect front-line troops using forward-located Patriot units. In accomplishing both missions, Patriot will track and shoot down many aircraft simultaneously while counteracting and evading enemy electronic jammers and will provide defense against air threats ranging from very-low altitudes to very high altitudes. Patriot performs this dual mission with less tactical equipment, greater fire power, improved electronic counter-countermeasure capability and simplified logistics and maintenance requirements compared to existing and previous surface-to-air missile systems (Bearce, 1985; DA, 1984b).

HISTORY OF SYSTEM ACQUISITION

Patriot development has lasted 15 years (USAADASCH, 1985d). Within the last year the first two Patriot battalions (4th Battalion, 3rd Air Defense Artillery and 2nd Battalion, 43rd Air Defense Artillery) have deployed to West Germany (Huston, & Hutchison, 1985; Jordan, 1985). There is also a Battalion at Fort Bliss, but it has no Patriot equipment (Crouch, 1985a).

PERSONNEL AND KEY JOB TASKS

Personnel assigned to Patriot operation and maintenance and their major duties are listed on Table C-1.

Once the system is emplaced and activated, only the Tactical Control Officer (TCO) and the Tactical Control Assistant are required to operate battery: only the ECS is manned at the FCS. Similarly, at battalion, the Tactical Director and the Tactical Direction Assistant are required to man the ICC for battalion control (DA, 1984b).

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

The major information displays at the ECS are two large plan position indicator (PPI) CRTs which display symbols corresponding to critical assets targets of different categories, friendly aircraft, missile flyout, target-missile intercept points, etc. Alphanumeric messages are also displayed related to target priorities, etc. The operators interact with the system via

Table C-1

Patriot MOSs and Major Tasks

MOS	Title	Duties/Tasks
16T	Patriot Missile Crew Member	Emplace Patriot System Erect radar and antennas Perform march orders Camouflage equipment Operate and reload launcher Operate power plant Activate radios (DA, 1983a)
24T	Patriot System Operator/Maintainer	Operate Engagement Control Station Operate Information and Coordination Central Maintain Patriot System (DA, 1983a)
14E	Air Defense Officer	Command/Operate Engagement Control Station Command/Operate Information and Coordination Central (DA, 1983a)

keyboards, push-buttons and toggle switches. A printer (hard copy unit) is available (DA, 1983b).

COMPUTER CAPABILITIES

The Weapons Control Computer (WCC) is a 24-bit, parallel, militarized computer with fixed- and floating-point capability. It is organized in a multiprocessor configuration and the major subsystems within the computer system are: 1) The Central Processing Unit (CPU); 2) The Input/Output Control Unit (IOCU); 3) The Monolithic Memory Subsystem (MM); and, 4) The Peripheral Control Unit (PCU).

The baseline WCC configuration consists of two CPUs, one IOCU and 524,288 words of main memory at the ECS and ICC. The Peripheral Control Unit connects a hard copy unit that provides printouts of selected tabular displays, fault detection/assessment data and communication messages received by the operator (when he presses the hardcopy key on the keyboard). The PCU also connects a magnetic tape unit that stores the complete contents of the computer memory in case of a nuclear electromagnetic pulse (EMP)FTX or other transient power surge which garbled or erased any portion of that content. The Mass Storage Unit (MSU) consists of four tape transports and associated interfaces. The MSU is

used for loading computer initialization programs, operation programs, embedded training programs and diagnostic programs into the WCC memory. The MSU has a storage capability of 672 million bits of data (DA, 1983b).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

Full simulation of key combat tasks of the air defense mission occurs during use of the embedded troop proficiency trainer (TPT). Only software is used to produce this full simulation indicating that the equipment has a totally self-contained capacity to simulate key combat tasks when the TPT is used (Raytheon, 1984). The upgraded live air trainer (LAT), which becomes available spring 1986, will only partly simulate air defense missions. This other Patriot embedded trainer will depend on targets of opportunity or field training exercises (FTX) designed to provide "targets" and nontargets (friendly aircraft) via the operating radar set. The LAT simulates missile firing, missile flyout, engagement of targets of opportunity and their destruction. Once "killed", symbols for these targets no longer appear on the PPI despite their "visibility" to the radar (Baugh, 1985).

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

The TPT evaluates the operators as well as training them but the current evaluation procedures consist only of 1) calculation of the percentage of asset-threatening targets destroyed and 2) the degree of total assets destroyed. There is no scoring of how quickly or orderly they are dispatched (Raytheon, 1984). The computer has more than adequate capacity for also measuring and scoring the latencies of operator responses to targets/nontargets, for quantitative scoring of the operator's target prioritization processes and for support of other quantitative techniques for evaluating operator performance during TPT use (DA, 1983b). It is our opinion, that appropriate software needs to be written to improve evaluation of operator performance during TPT use both to improve feedback for operators and their evaluators and to increase motivation for operator training.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

Contractor (Raytheon) New Equipment Training (NET) for the Patriot weapons systems was already completed at the time the March, 1983 ICTP was published (DA, 1983a). This NET included the Staff Planners Courses, Technical Orientation Courses, Operational Test II courses, Paper Instructor and Key Personnel (I&KP) Courses, Hardware I&KP training and component design confirmation training all of which had been completed by March, 1983. Training for the first two battalions was also considered part of New Equipment Training because Raytheon conducted the training. However, this training was conducted with the assistance of US Army Air Defense Artillery School (USAADASCH) personnel. Subsequent battalions were trained exclusively by USAADASCH personnel (DA, 1983a).

This "cohort" individual training and collective (packet) training continues and will remain the major ongoing institutional training effort for the next several years until all 12 Patriot Battalions are deployed. Training of unit replacement personnel will gradually displace this collective training and become the major institutional training effort. "Transition" courses for retraining existing personnel are already being eliminated as newly enlisted personnel begin to form the major student body (Ross, 1985).

EXISTING/PROPOSED INSTITUTIONAL TRAINING

The following courses for Patriot operators and crewmen are taught at the Army Air Defense Artillery School in Ft. Bliss, Texas:

1. 16T Patriot Missile Crewmember Course

This is a 14-week and two-day OSUT course or eight-week and two-day non-OSUT course (USAADASCH, 1985b) of which 288 hours are designated for Patriot-peculiar training in the following MOS-specific subjects:

a. Introductory Classes
b. Safety (Radiation, Electrical, etc.)
c. System Peculiar Communications
d. Orientation to the Patriot System
e. Emplacement of the Complete System
f. March Order of the Complete System
g. Launcher Reload
h. System Preventive Maintenance
i. Operate Electrical Power Plant II (EPP II)
j. Operate Launcher
k. Operator Maintenance on EPP II
l. Provide Maintenance Assistance for Patriot Mechanic (DA, 1983a)

The 16T course is a prerequisite to any 24T/222C course (DA 1983a).

2. 24T/222C Patriot Operator and System Mechanic Course

This is a 37-week and two-day course (USAADASCH, 1985c) that consists of the following subjects:

a.	Basic Electronics	4	140
b.	Digitec	3	105
c.	Operation & Tactics	5	175
d.	Radar Maintenance	10	350
e.	ECS	4	140
f.	ICC	3	105
g.	LCHR	7	245
h.	IFF	2	70
	TOTAL	38	1330

Warrant Officers have an additional 10 weeks of analog and digital training scheduled in their course (DA 1983a).

3. 14E Patriot Officer's Course

This nine-week and four-day course (USAADASCH, 1984) will include training in the following subjects:

a. Patriot Air Defense Weapon System
b. Patriot Battalion Communications
c. Patriot Battalion Power Equipment
d. Patriot March Order & Emplacement Procedure
e. Fire Unit Initialization
f. Air Defense Mission
g. Launching Station Orientation and Missile Reload Procedures
h. Battalion Organization
i. Patriot Tactics
j. Patriot Logistics and Maintenance Concept (DA, 1983a)

An important training device used in institutional training for both the 24T and 14E MOSs is the Patriot Conduct of Fire Trainer (P-COFT). There are seven P-COFTs in use in institutional instruction at USAADASCH. The P-COFTs were produced by Sanders Associates. Each P-COFT can train eight students, either individually or collectively. The P-COFTs provide simulations/stimulations of the Patriot system displays, controls, communications, and data processing systems. The eight student operator consoles are controlled and monitored by the instructor's control group console. The student consoles are designed to allow students to perform all actions related to system initialization, automatic operation and semiautomatic operation. The P-COFT also teaches the monitoring, proper use of and response to weapon displays, controls, communications and data processing systems. Operators (14E and 24T) are trained to operate at both the Battalion level (ICC) or Battery level (ECS) and training is provided on both configurations with the P-COFT (DA, 1983a; Gussett, 1985).

The 24Ts not only learn to operate the equipment, they also learn to maintain it (Bromberg, 1985). Another important training device is the institutional Patriot Organizational Maintenance Trainer (POMT). The POMT consists of portions of Fire Control Stations which are housed in a large building. The equipment is "opened up" and these expanded equipment configurations allow easy access for individuals and groups to troubleshoot Patriot malfunctions (USAADASCH, 1985a).

The POMT equipment includes a simulated ECS, simulated radar set, simulated display and control console, and simulated final modulator-power supply. It can provide 147 different simulated hardware maintenance training tasks. Students are presented with realistic symptoms of malfunction and are required to use prescribed publications along with DAM, non-DAM, and BITE indicator procedures to diagnose, locate fault, remove/replace defective components and use software routines to verify that the fault has been corrected (USAADASCH, 1985a).

EXISTING/PROPOSED UNIT TRAINING

Embedded training is a key feature of the Patriot System and soon there will actually be two embedded training packages for operator training. A "simulator" known as the TPT is a set of software that resides in the computer of the ECS and in the information and coordination central (ICC) computer. The software provides the Patriot operator with the capability to practice air defense artillery exercises against an air threat on the ECS or ICC using simulated radar signals and launches. An important feature of the TPT is its capacity to synchronize training of the ECS operators with the training of battalion ICC operators through use of "netted scenarios." This trains operators in the normal mode of operation which is a battalion-directed air defense posture. Training of enlisted and officer operators in target detection, target acquisition, target identification and target engagement in an ECM environment can be accomplished with this device (Crouch, 1985b; Raytheon, 1984).

There are currently 17 air defense artillery scenarios developed for the TPT from which a set of five are installed each quarter by the Battalion Training Officer into five tracks of the A4 cartridge in the mass storage unit. The Battalion Officer (in the ICC) or Battery Officer (in the ECS) can load/run any one of the five available scenarios at any time; but cannot reload any of the other 12. Replacements will consist of alternate selections of the original 17 scenarios with subsequent new scenarios delivered as required. Twelve of these 17 scenarios are "3-netted", i.e., they involve the Battalion and three Batteries. Two scenarios involve only the Fire Control Section (Battery) and three involve only the Battalion ICC (Crouch, 1985a; 1985b).

The prime equipment is unmodified during use of the TPT and switching from operation to the TPT and back takes as little as one minute! Current scenarios do not represent the specific assets of the NATO positions of the individual unit(s) although this is planned for later implementation (Crouch, 1985a).

The other embedded training system is the live air trainer (LAT). This is a software system which disables the launchers but leaves all other components operational including the radar, simulates missile launch and flight, and allows Patriot operators to simulate the engagement of actual air traffic ("targets of opportunity") within radar range. Once an aircraft is "shot down", the computer deletes it from the CRT. A version of the LAT is available now and is limited to simulated target engagement, missile launch and destruction. When an upgraded version (Post Deployment Build [PDB-1]) of the LAT is shipped to operational units in spring of 1986, it will add variety to operator training on a day-to-day basis. The PDB-1 version will include simulated system engagement, missile launch, missile flyout and destruction. The LAT will also be particularly useful during the infrequent training exercises when NATO air forces participate and fly both offensive and defensive sorties. The Patriot operator and tactical control officer displays will then be identical to the displays during an actual engagement with the exception of a CRT message that clearly indicates that this is a training mode (Baugh, 1985; Welch, 1985).

We did not learn of any embedded training or other unit training of maintenance skills. Presumably, supervised experience on the job is expected to provide such sustainment training for the maintenance tasks of the 24T MOS.

UNIT TRAINING COSTS

Tape cartridges for storage of TPT scenarios are very expensive ($31,000.00 each) and preparation of new TPT scenarios would be costly for this reason alone without the requirement of a man-month of effort in their development (USAADASCH, 1985c). Generator fuel for the ECS or ICC during embedded operator training apparently is not a factor since the equipment must be powered up anyway.

SHIFT FROM TRAINING TO OPERATIONS MODE

Since the TPT is embedded software (i.e., programs with associated software scenarios) the prime equipment is unmodified during use and it does not require any connecting or disconnecting of cables. Switching from normal system operation to the TPT and back takes on the order of one to three minutes. A simple, software-cued operator reconfiguration of the Patriot system allows the TPT software to be used and at the same time restricts the use of the actual radar and launchers. An operational system is needed for only the ECS or ICC so that there is no need to power up radar or launchers (Crouch, 1985a; 1985b).

There will also be only a few minutes required to use the LAT or to change back from the LAT to normal system operations (Baugh, 1985).

TRAINING MANAGEMENT

The battalion commander has overall responsibility and authority for training his firing batteries. Through his officers, warrant officers and NCOs, the commander strives to develop a combat ready force that is physically and psychologically prepared to fight and win a global war (DA, 1984b).

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

Sterback (1985) indicated that the TPT was being used to provide operator training on a daily basis in the first unit deployed to West Germany.

ADEQUACY OF TRAINING SYSTEM

The TPT was extensively used in garrison settings for preparing the 4/3 ADA Battalion for the successful Follow on Evaluation III that led to their deployment to Germany (Huston & Hutchison, 1985). Sterback (1985) described the daily use of the TPT in the 4/3 in Germany and had no doubts about the

ability of the deployed Patriot Battalions to successfully achieve their air defense mission. However, Sterback (1985) was concerned that the ICC operator task could become too difficult to perform optimally when six ECSs replace the current three per ICC in FY 87. A switch from the semiautomatic Patriot mode of operation to the automatic mode was seen by Sterback (1985) as the best solution to this future problem although intense unit training would at least increase performance if the semiautomatic mode were retained. The use of automatic versus semiautomatic mode is an operational question that is much debated within the Air Defense community.

IMPEDIMENTS TO TRAINING

When using the TPT, power is only needed for the ECS or ICC and not for the radar or launchers (Crouch, 1985b). ECS/ICC power will be required anyway and fuel cost or generator wear will not be a reason to avoid unit training with the TPT (Sterback, 1985). Radar power is needed for the LAT, but this is a relatively minor factor and should not lead to restrictions on embedded training using the LAT (Baugh, 1985). The LAT also allows airspace monitoring during training unlike the TPT which disables the radar.

The effectiveness of TPT training is somewhat diminished as a result of the current small number of scenarios. We were repeatedly told that four or five presentations of a scenario virtually exhausted its training potential. It is reported that maximum training value occurred during the first presentation when operators did not know where to look for targets and, as a result, were highly stressed by the tasks of target detection, target identification, target prioritization, etc. (Bird, 1985; Sterback, 1985). Novel scenarios that challenge skilled operators appear to be a key to maintaining effective training with the TPT. Resources should be allocated for development of numerous scenarios and perhaps for development of even easier procedures to generate novel scenarios and/or to modify existing scenarios. The new capability of translating P-COFT scenarios for use with the TPT should be fully exploited. If P-COFTs are eventually shipped to Germany, one should have TPT scenario-development and translation capability for theatre specific scenerio development.

It could be that scenarios would not lose their training value after repeated presentations if operator performance were evaluated in a more comprehensive manner than by the current percent-targets-killed formula. If operator reaction times for tracking, engaging and killing targets were measured, operators could strive to improve their performance on repeated presentations. Research is needed to see if improved techniques for operator performance measurement can add to the training value of the TPT.

The LAT is not currently available for training but this will be corrected in April, 1986. Current limitations of the LAT such as the failure to display missile flyout on the PPI will be corrected by the upgraded PDB-1 version (Baugh, 1985; Welch, 1985).

SUMMARY

The Patriot Surface-to-Air Missile System consists of three battery fire control sections, the battalion information and coordination central set, three electronic-scanning radars (1 per battery), communications relay groups, twenth-four launcher sections (eight per battery) with four missiles each and transportation and maintenance elements. The expansion of Patriot battalions is planned to start in 1990; this will increase the number of batteries from three to six per battalion. An earlier expansion, planned for 1988 will increase the number of launchers from eight (8) per battery to sixteen (16) per battery (Crouch, 1985).

A computer in the engagement control station (ECS) of each fire control section controls the radar and launching stations, automatically appraises target threat, selects an appropriate response and guides the missile to the target. In the semi-automatic mode, operators select and engage targets that the system has detected and evaluated. Patriot can also function in an automatic mode where operator selection of targets is not needed although delays can be built into system operation so that operators have the opportunity to veto automatic system choices.

The capabilities of the Patriot Surface-to-Air Missile System to evaluate and simultaneously engage multiple targets at very high and very low altitudes are truly remarkable. What is more, once emplaced and activated, Patriot is so completely automated that the air defense mission can be carried out by one operator and one tactical control officer in the engagement control station.

Sophisticated training devices exist both in the school and the unit for training these key Patriot ECS personnel. The institutional trainer is known as the Patriot Conduct of Fire Trainer (P-COFT) and it provides a complete simulation of combat stimuli including the displays that represent the responses of the Patriot system when operators engage these simulated targets. This is a remarkable "arcade-game" display of symbols that represent multiple moving targets, friendly aircraft, missiles in flight, projected intercept points (which also move as targets change course), killed targets, etc. A large number of scenarios exist that train different air defense missions and more are being developed on a continuing basis including ones which will be tailored to areas actually defended in Europe.

The troop proficiency trainer (TPT) mimics the P-COFT, but provides its operator training on the operational equipment itself. It is an embedded unit trainer which requires only the calling up and running of computer programs that exist within the Patriot system computer. The TPT can be activated or deactivated in one minute. About 20 different scenarios exist which provide comprehensive operator training including full simulation of normal Battalion-directed air-defense missions. It is now possible to translate P-COFT scenarios for use on the TPT and these extra scenarios will increase training potential of this embedded trainer.

There is another embedded training system for the Patriot System that will be fielded in the Spring of 1986. It is the live air trainer (LAT) and uses the Patriot radar set to provide targets for operator training. The

launcher is disabled and the LAT simulates launch and flight of missiles when the aircraft that appear in range are fired on. Such "targets of opportunity" will differ greatly in number and behavior from the simulated enemy aircraft appearing during TPT use (and from real attacking aircraft). Day-to-day training with the LAT would probably have only moderate value, especially if novel or otherwise challenging scenarios were available for the TPT. The LAT will come into its own during FTXs when NATO air forces fly missions that simulate attacking and defending aircraft.

These two embedded training packages, if used appropriately, should insure that operational readiness will not suffer from a lack of operator training. Novel scenarios that challenge skilled operators appear to be a key to the effective use of the TPT. Resources should continue to be allocated for development of numerous scenarios and perhaps for development of even easier procedures to generate novel scenarios for training and/or development of procedures to modify existing scenarios. If P-COFTs are eventually shipped to Germany one should have TPT scenario development and translation capability for theatre specific scenerio development.

Whereas the TPT is judged to be an excellent trainer, the operator performance scoring that it also provides often indicates better performance than actually occurs. Scenarios and scenario scoring need to be changed to improve the current evaluation of operator performance with the TPT. Improved automatic scoring of TPT performance could potentially prevent the current high scores that often cause operators and commanders to believe that performance is better than it is. Operator reaction times for tracking and firing on threat targets might be used in addition to the current kill/no-kill scoring.

Not all of the problems we found in our study of the Patriot System were training problems. In some units 24T Patriot operator/mechanics become exclusively operators or exclusively maintainers. SQT performance of both groups will undoubtedly suffer from the lack of experience with half of their job. On the other hand, job performance of both groups may be higher as a result of this logical division of labor. Perhaps a revision of the 24T MOS structure with separate skill identifiers or even separate MOSs is needed.

There also appears to be a problem with the major emphasis on camouflage during the frequent Patriot moves in peacetime training. This makes the job of the 16T Patriot Missile Crew Member extremely arduous. Reenlistment in the 16T MOS probably will be low until some of these problems are worked out.

The failure to take advantage of the Patriot system's automatic target evaluation and engagement capabilities is felt to be another problem by many Patriot personnel. The Air Force is concerned that friendly aircraft might be shot down in the automatic mode. Aircraft missions need to be flown which will determine whether the Patriot System falsely designates friends as foes. If the system is as reliable as many experienced operators believe, more dependence on the fast automatic mode of operation <u>may</u> be appropriate. If so, this could alleviate the effects of expected shortfalls, particularly when the number of Fire Control Sections is increased from three to six per Battalion in 1988.

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APPENDIX D

TACTICAL FIRE DIRECTION SYSTEM (TACFIRE)

CONTENTS

APPENDIX D

TACTICAL FIRE DIRECTION SYSTEM (TACFIRE)

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Field Artillery Tactical Fire Direction System

2. System Components:

The TACFIRE System consists of the TACFIRE Computer and remote devices located within the computer's area of control. The component elements of the TACFIRE Computer will vary in quantity depending upon which functional level it controls - Corps, Division, Brigade or Battalion (Department of the Army, [DA] 1984a).

a. TACFIRE Computer

The major computer components and support elements are shown in Table D-1. The table also shows the distribution of elements at the two levels.

Each computer consists of three component groups: the computer group, the display group and the communications group. The computer group handles system operations, performs calculations, processes programming information and stores data. The display group provides the means for operators to enter and retrieve data, display data, and control the computer's operations. The communications group allows the system to digitally communicate with other computers and remote devices (DA, 1984a; US Army Field Artillery School, [USAFAS], Undated e).

b. Remote Devices

1) Variable Format Message Entry Device (VFMED)

The VFMED provides access to a TACFIRE Computer for data entry and retrieval. It has no computational capability (a dumb terminal). It is located at the Fire Support Element, the Laision Element and at the Operations, Intelligence and Targeting Section.

The VFMED consists of a power distribution unit, a KG-31 COMSEC device, a remote data terminal (RDT), an electronic line printer (ELP), a keyboard and display editor. The display editor, keyboard, ELP and KG-31 are interchangeable with their counterparts in the TACFIRE computer. The VFMED can be transported by or mounted in 3/4 ton or larger trucks. The TACFIRE Operations Specialist (MOS 13C10) is specifically trained to operate this remote device. It is used primarily for fire planning by the FA Forward

Table D-1

Distribution of TACFIRE Components by level.

TACFIRE Component	Corps, Division,Brigade	Battalion
Computer Group		
Central Processing Unit	1	1
Input/Output Unit	1	1
Mass Core Memory Unit	1	1
Magnetic Tape Unit	2	1
Display Group		
Artillery Control Console	1	1
Digital Plotter Map	1	1
Electronic Line Printer	2	1
Electronic Tactical Display	1	0
Communications Group		
Keying Generator KG 31	1	1
Digital Data Terminal	7	6
Communication Control Unit	1	1
Remote Communications Monitoring Unit	3	2
Communications Terminal Box	1	1
J-1077 Distribution Box	3	3
Communications Patch Panel	1	1
Communications Junction Box	1	0
Power Supply and Maintenance Group		
Power Converter Group	2	1
Module Test Set	1	1
Power Entry Panel	2	1
Generator Set, AN/MJQ-15	2	1
Prime Mover		
Truck, 5-Ton	4	2

Support Element located at the supported tactical unit, the laision element located with adjacent units for coordinating fire missions/planning, and the Operations/Intelligence (S2/3) and Targeting Sections of the TACFIRE computers parent Tactical Operations Center (TOC) (DA, 1984a; USAFAS, 1985b, 1985c).

2) Digital Message Device (DMD)

The DMD transmits and/or receives fire, intelligence, location, FLOT, plain-text messages and more. It has limited buffer storage capacity. It is located with the Forward Observers, Aerial Observers, Sound Ranging Teams, Radar Teams and Lading Teams.

The DMD is a two-way, 10 pound, one-man-portable tactical digital message communications terminal. It can communicate on one net to TACFIRE computers, Battery Computer Systems (BCS), Fire Support Team DMDs (FIST DMD), and other Forward Observer DMD's by use of standard Army radios or field wire. The DMD can transmit and/or receive requests for fire, artillery target intelligence messages, messages to observers, the observer's location, plain-text messages, fire plan targets, FLOT and more. The DMD can interface with the ground/vehicular laser locator designator (G/VLLD) for target locations only. Voice transmissions are required to assist in processing Hellfire and Copperhead missions. The DMD has two active fire mission buffers and seven off-line message buffers (DA, 1984a, 1984c; USAFAS, 1982).

3) Fire Support Team Digital (FIST DMD)

The FIST DMD transmits, receives and relays messages. It has four net, 20 subscriber capability and stores up to 16 messages. It provides review, automatic and replay modes. It also provides command and control function at the line Company and Battalion levels. It is located with the FIST Chief and the Battalion Fire Support Officer (FSO).

The FIST DMD is an 18-pound, man-portable tactical digital message communications terminal with limited computational functions. It can transmit, receive and relay messages to any digital communications device on up to four digital nets by use of standard Army radios or field wire. It enables the FIST Chief to coordinate the fire support requirements of his forward observers. The Battalion FSO uses a FIST DMD to coordinate fire support with the FISTs and the battalion mortar platoons, which have mortar fire control calculators (MFCC) (DA, 1983c, 1984a; USAFAS, 1982, 1984c).

4) Battery Computer System (BCS)

The BCS is an automated data processor and communication terminal. It computes individual gun fire commands at battery level and sends these to the guns. It is located with the FA Firing Battery.

The Battery Computer System, gun direction, AN/GYK-29V, is an automated data processor and communications terminal that interfaces directly with TACFIRE. It consists of three major units: the battery computer unit (BCU); the power distribution unit (PDU); and, 1 to 12 gun display units (GDU). The BCS optimizes effects on the target area by computing individual fire commands for each weapon. Since the BCS can compute individual aiming points and firing data, the firing battery can occupy a larger area, making it less vulnerable to counterfires. The BCU communicates with the GDU's via standard Army radios or field wire. The BCS has an embedded training system under development as a strap-on component called the BCS Integrated Training System (BCS-ITS) (DA, 1983c; USAFAS, 1984a).

c. Related Fielded Systems

1) Multiple Launch Rocket System (MLRS)

The MLRS uses a BCS (called Fire Direction System (FDS) for MLRS application) for fire direction at battery and battalion levels. The self-propelled loader-launcher (SPLL) contains its own fire control computer. The FDS accepts fire orders from TACFIRE, passes orders to the SPLL which computes its own fire data and fires mission. This system also contains a Platoon Leader's DMD (PLDMD) which performs the same functions as the FIST DMD but has four communications channels - one to the FDS and three to the platoon SPLLs. The PLDMD is unique to MLRS.

The Multiple Launch Rocket System (MLRS) consists of a battery computer unit with MLRS specific software, the platoon leader's digital message device and the self-propelled-loader-launcher configured into a battery sized formation. Each SPLL is capable of operating independently or in platoon/ battery firing formations, capable of engaging area type targets with 12 rockets per salvo prior to reload. The SPLL has a mounted lift-hoist which makes it capable of loading its own rocket resupply from any conventional resupply vehicle. The MLRS battery has its own tracked ammunition resupply vehicles. The SPLL fire direction system has an embedded training package available at unit level similar to the institutional training system (DA, 1983c; Signorelli, 1985).

2) Firefinder Radar System (AN/TPQ-36 and AN/TPQ-37)

In terms of interfacing with TACFIRE, these radars are functionally identical. Both report target information and requests for fire using a DMD emulator.

The Firefinder Radar system is an automated weapons locating radar system consisting of two separate radar systems: the AN/TPQ-36 and the AN/TPQ-37. The AN/TPQ-36, Firefinder Mortar-Locating Radar Set, is a phased-array radar system which uses a combination of radar techniques and computer-controlled signal processing to detect, verify and track mortars, short-range artillery and rockets at ranges from 0.75 to 24 kilometers. It can handle multiple targets simultaneously, passing target information to TACFIRE for counterfire measures (DA, 1984c, 1984d).

The AN/TPQ-37, Firefinder Artillery-Locating Radar Set, operates essentially the same as the AN/TPQ-36 with the exception of increased range. The published first round detection range is 3 to 50 kilometers, depending upon weapon type. A division complement of these radar systems is three AN/TPQ-36 radar sets (8 men each) and two AN/TPQ-37 radar sets (12 men each) assigned to the Target Acquisition Battery of Division Artillery (DA, 1984c, 1984d).

d. Related Developmental Systems

1) Remotely Piloted Vehicle (RPV) (Aquila)

The Aquila performs target Acquisition, combat information and reconnaissance and provides targets and information from up to 20 km beyond the FLOT. A DMD is used to pass digital messages to the TACFIRE.

The Field Artillery RPV presently under development and soon to undergo operational testing (July 1985), consists of a radio controlled, remotely piloted miniature aircraft with a nose mounted camera, sensors and G/VLLD. The Aquila RPV system is manned by a pilot and sensor monitor. Specific data collected by the RPV can be transmitted to the TACFIRE computer via a DMD over standard Army radios or field wire (DA, 1983c, 1984c; See the Aquila System Report).

2) Meteorological Data System (MDS)

The MDS performs automatic collection, processing and transmission of meteorological data. It transmits these data to TACFIRE for relay to FDCs for ballistic calculations. The MDS provides computer ballistic and fallout meteorological messages to the computer system with which it operates. The computer, in turn, sends these meteorological messages to all other users. The MDS has a Relay Data Terminal (RDT) identical to that of the VFMED to translate the on-board computer's language to digital messages (and vice versa). Operators keyboard actions are basically identical to those used with a VFMED (DA, 1983c, 1984a, 1984b).

3) Advanced Field Artillery Tactical Data System (AFATDS)

The AFATDS is an evolutionary system with TACFIRE as the base line system. It will have multiple processors and greatly decreased size and weight. It will provide automated command, control and coordination for the Field Artillery.

The AFATDS system will consist of several linked microprocessors, each having a specialized Field Artillery command and control function. These microprocessors will be of a small size, lightweight, "suitcase" variety with expanded memory capability (see the AFATDS system report).

MISSION

TACFIRE was designed to automate selected Field Artillery command and control functions to provide more efficient management of the fire support resources of a force element of Corps, Division or Brigade size. To achieve this mission, TACFIRE provides an integrated system of fire control complexes that use digital computers, remote devices, graphic display units, control consoles and other equipment combinations appropriate to the function performed (DA, 1984a).

HISTORY OF SYSTEM ACQUISITION

TACFIRE Phase I development began in 1966. Developmental/operational Phase II testing was conducted from November 1974 to September 1977 at the 1st Cavalry Division DIVARTY. In January 1975, the Deputy Secretary of Defense gave approval for the Army to proceed with a limited procurement (LP) phase of TACFIRE development. With this decision, the contractor (Litton Data Systems) was authorized to begin production of sufficient amounts of TACFIRE equipment (11 Battalion and 3 DIVARTY Fire Direction Centers and associated remote equipments) to be used by the Army for further testing and evaluation of the system leading to a decision of whether or not to begin full-scale production (FSP). MOD P00 190, signed in March 1978, authorized ten additional systems to be produced for use by the Army. The system was type classified "A" and initial issue begun in 1980 (Dies, 1985; USAFAS, 1978).

USAREUR and Korea are at 100% fill with CONUS at 80% fill (Bray, 1985). Congress has been reluctant to procure additional systems due to perceived operational difficulties with this system and because it is already a technically obsolete system. USAFAS personnel have indicated that there are no additional monies available for upgrading operational or training capabilities of this system. The possibility of producing interactive videodiscs for TACFIRE operator training comes from resources not specifically identified for TACFIRE (Dies, 1985).

PERSONNEL AND KEY JOB TASKS

The major MOS, Grade and position descriptions for TACFIRE operations and maintenance are shown in Table D-2.

In our interviews, we were repeatedly told that the tasks of the TACFIRE computer operator are among the most perishable of all soldier tasks that exist in the Army (Bray, 1985; Dies, 1985; Hawking, 1985; Suzuki, 1985; Wu, 1985). For this reason, TACFIRE may be the Army system most in need of effective embedded training or some other form of unit training for its 13C operators. Watching people operate the TACFIRE computer largely confirmed these comments. The demands on the operator's memory are incredible. There are a total of 160 different message formats involving 411 TACFIRE-system-specific mnemonics (USAFAS, Undated e). The operator has minimal prompting, cuing or instructions for their use in the operational software. Optional and mandatory entries for each format exist but the software does not specify which are which. The operator must constantly refer to the 10 volume operator's manual for reference. One partial solution to the perishability of operator tasks would be to redesign the operational software to reduce the large operator memory requirements. However, additional funds to reconfigure TACFIRE software or hardware apparently are not available (Dies, 1985; Suzuki, 1985).

Given the difficulty of TACFIRE computer operation, only the higher skill levels of the 13Cs routinely operate the computer. The need for refresher training for these senior NCOs may not mesh with traditional beliefs that senior NCOs are already fully trained (DA, 1985, 1983a, 1983b; US Army TRADOC Systems Analysis Activity [TRASANA], 1985).

Table D-2

TACFIRE Personnel: MOS, Grade and Duty Positions

MOS	Grade	Duty Position and Tasks
13C10	E1-E4	TACFIRE Operations Specialist (DA, 1983a) Operate and maintain 15 KW and 4.2 KW Generator Sets Install and operate the Variable Format Message Entry Device (VFMED) Install and operate message encryption devices; use a numeral cipher/authentication system Maintain and troubleshoot the VFMED Shutdown the VFMED Install various radios, establish, enter and leave a radio net Install, remove and repair communications wire lines Install and maintain appropriate antenna Map reading Maintain an M60 machine gun Maintain a restricted area
13C20	E5	TACFIRE Equipment Specialist (DA 1983b) Install, cable, perform power-up and shut-down procedures of TACFIRE computer system Prepare and operate the Digital Plotter Map Perform daily, weekly, monthly and quarterly Preventive Maintenance Checks and Services (PMCS) on the TACFIRE computer system Troubleshoot, isolate, locate and replace faulty system components Alter/reconfigure computer components to operate in a degraded mode
13C30	E6	TACFIRE Computer Operator (Battalion Level) (DA, 1983b) Initiate, process, modify, coordinate, validate and activate computer data files specific to the Field Artillery Battalion function Initiate/process standard, nonstandard and nuclear fire missions Process specific function reports Identify and take corrective action for error messages Display Tactical and Fire Mission data on the Digital Plotter Map

Table D-2

TACFIRE Personnel: MOS, Grade and Duty Positions (continued)

MOS	Grade	Duty Position and Tasks
13C40	E7	TACFIRE Computer Operator (Corps, Division, FA Brigade Level) (USAFAS, 1983b) Enter, modify, validate, disseminate, initiate, process, compute and coordinate computer data files specific to the Corps Artillery, DIVARTY, and FA Brigade missions Display Tactical and Fire Mission data information on the Digital Plotter Map and the Electronic Tactical Display Initiate/process a standard, nonstandard, and nuclear fire mission Identify and take corrective action on error messages Process specific function reports
13E	E1-E6	Cannon Fire Direction Specialist (USAFAS, 1984a; USAFAS, 1984b) Communications Map reading Operate and maintain the Battery Computer System Use manual techniques for computing firing data
13F	E1-E6	Fire Support Specialist (USAFAS, (1984c) Communications Map reading Use of G/VLLD Forward Observer duties Use of Digital Message Device Operate and maintain wheeled vehicle
34Y	E1-E6	Field Artillery Tactical Fire Direction Systems Repairer (DA, 1985) Remove, replace, repair, salvage and install TACFIRE equipment Apply Modification Work Orders Isolate and diagnose malfunctions Interpret complex schematic diagrams Perform final inspection and testing Maintain maintenance records

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

The major information displays on the TACFIRE computer are two monochrome CRTs which present alphanumeric information. One CRT displays incoming messages and the other displays messages as the TACFIRE operator writes them. In addition, many pushbuttons are illuminated when activated.

At Battalion level a map plotter provides battlefield information. At Division Artillery level both the plotter and a large CRT are used to represent battlefield information. A printer is available at both levels.

Operators interact with the system primarily via a standard keyboard but many pushbuttons are involved for selection of 64 message formats on an 8 by 8 matrix, etc. (DA, 1983b, 1984a; USAFAS, 1985c, Undated d, Undated e).

The indicators and controls for the TACFIRE computer components consist of standard pushbuttons, knobs, dials and meters found on any electronic equipment (DA, 1983b, 1984a; USAFAS, 1985c, Undated d, Undated e).

The VFMED operator console is almost identical to the TACFIRE computer operator's console except that it has only one CRT for information display. Otherwise, all other controls and indicators are identical. Displays, indicators and controls on VFMED components are standard pushbuttons, knobs, dials and meters (USAFAS, 1985c).

COMPUTER CAPABILITIES

TACFIRE has a large, but outdated, computer with a memory capacity of 393K 32-bit words (524K at Division/Corps Artillery). There is a magnetic tape unit in addition to the keyboard for information entry. This magnetic tape system is somewhat unreliable and frequent replacement of the fragile tapes is required (at $703/blank cassette) (DA, 1984a; USAFAS, Undated e; Bray 1985; Dies, 1985; Hawking, 1985; Suzuki, 1985).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

Team training tapes and a former hands-on SQT both demonstrate such a capacity. However, use of this capacity has been limited. We learned that much more elaborate simulation of inputs from observers, equipment and artillery would be possible if new team-training/testing software were written (Dies, 1985; Hawking, 1985; Suzuki, 1985).

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

The team training tapes and Skill Qualification Test (SQT) also demonstrate that this capacity exists. However, use of this testing capacity

has been even more limited than the simulation capacity (Bray, 1985; Dies, 1985; Hawking, 1985; Suzuki, 1985).

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

The team training scenarios were recommended by the contractor (Litton Data Systems) and developmental software and scenarios were ordered by the government early in system acquisition. The computer assisted instruction (CAI) system was originally developed for institutional training by the Army Research Institute (Wu, 1985). The CAI system became part of the exportable training package (USAFAS, Undated a). The other parts of the exportable training package were developed by the TACFIRE Training Support Group as part of the normal unit training effort and tailored to specific developing training needs (Suzuki, 1985). Present financial constraints limit the further refinement of embedded training efforts for the exportable training materials (Suzuki, 1985). A shortage of system hardware is indicated as a constraint in institutional training (Bray, 1985; Dies, 1985).

EXISTING/PROPOSED INSTITUTIONAL TRAINING

Institutional Courses

The following courses are offered at the USAFAS as resident courses for TACFIRE operators and maintainers (USAFAS, 1984d).

a. TACFIRE Operations Specialist

This 4 week and 4 day course exposes the student to the capabilities of the TACFIRE system: general characteristics of TACFIRE equipment; basic TACFIRE organization, applications, and operating procedures; knowledge of the Variable Format Message Entry Device (VFMED); knowledge of the practical application of field artillery operations to include the duties, responsibilities, and missions of personnel working in a TACFIRE equipped Tactical Operations Center; and, the use of TACFIRE Technical Manuals. Course completion results in award of MOS13C10. The course Program of Instruction (POI) lists the following breakdown of instructional methods and hours: Classroom Instruction - 35.9 hours; Practical Exercise (Individual) - 89.6 hours; Practical Exercise (Team) - 17 hours; Programmed Instruction Booklets - 20 hours; Computer Assisted Instruction (CAI) - 10 hours; and a total of 172.5 (USAFAS, 1984d).

b. TACFIRE Fire Support Course

This 11 week and 3 day course trains the TACFIRE Computer Operator (Enlisted) and the Fire Support Officer (Officer) the capabilities of the TACFIRE system. It covers characteristics of all TACFIRE equipment: TACFIRE organization, applications and operating procedures; knowledge of the practical application of automatic data processing to include the duties, responsibilities and missions of personnel working in a TACFIRE equipped Fire Direction Center either at FA Battalion, Division Artillery, Corps Artillery or

FA Brigade; and, the use of TACFIRE Technical Manuals. Completion of the course results in the award of the 4F Additional Skill Identifier (ASI). The Course Program of Instruction (POI) lists the following instructional methods and hours: Classroom Instruction - 153 hours; and, Practical Exercise (Individual and Team) - 205 hours, for a total of 421 academic hours (USAFAS, 1984d).

c. FA Tactical Fire Direction Systems Repairer

This 10 week course provides maintenance and repair training to produce the 34Y10 MOS. Detailed descriptions of POIs were not available.

d. General comments on courses

The TACFIRE Operations Specialist course is an entry level Advanced Individual Training (AIT) course for soldiers completing Basic Training. This four week and four day course exposes an individual to the TACFIRE system as a whole, but only trains him to operate and be familiar with the Variable Format Message Entry Device (VFMED) which is a remote device and not a part of the TACFIRE computer itself. The operator is trained through classroom instruction, programmed texts, computer assisted instruction and practical exercise to interact with the TACFIRE computer via the VFMED. These expose the operator to the message formats specific to those functions which utilize the VFMED (e.g.: Fire Support Element, I and O Sections and Liaison Elements). These functions update TACFIRE computer data files and read those data files. There is no training element in the POI that trains the 13C10 TACFIRE Operations Specialist to operate the TACFIRE computer. The critical task listings in the Soldier's Manual do not require the 13C10 to have any skills or knowledge about the TACFIRE Computer itself. The 13C10 Soldier's Manual lists 32 tasks, of which 24 are school trained and 8 are unit trained. None of the 8 unit trained tasks are TACFIRE equipment operation related (DA, 1983a).

There are 28 tasks listed for the 13C20 TACFIRE Equipment Specialist none of which are school trained. Skills and knowledge required for this skill level are all acquired through supervised on-the-job training (SOJT) at the unit. The 28 tasks are all TACFIRE computer specific and require the 13C20 to install, operate, troubleshoot, repair and maintain the computer and it's component devices (DA, 1983b).

The TACFIRE Fire Support Course is not an MOS producing course, but does produce an ASI. Eligibility for this course requires enlisted personnel to be in grade E4 or above, on active duty and qualified in MOS 13C, or to be an E3 selected from AIT (USAFAS, 1984d, 1985a). Officers must be First Lieutenant or above and selected by DA or their unit commander (USAFAS, 1985a). Officers attending this course are awarded the ASI of 4F and are usually assigned as Fire Support Officers at FA Battalion or Division Artillery level or with maneuver battalions (USAFAS, 1985a). Enlisted personnel attending this course are generally in grade E6 or above and are either TDY from their units or TDY enroute to new units. The TACFIRE Fire Support Course is a TACFIRE Computer Operator course which trains operators to interact with the computer: entering; manipulating; changing; and, generating multiple reports for use by its subscribers. Operators are trained to install, operate, troubleshoot, repair

to the lowest replaceable unit (LRU), and breakdown the TACFIRE computer and its component devices (DA, 1985: USAFAS, 1985a).

EXISTING/PROPOSED UNIT TRAINING

Exportable training materials fall into four categories. One is computer assisted individual instruction which was developed using the PLANIT instruction development language (Wu, 1985). This individual embedded training exists only for DIVARTY personnel, not for the numerous computer operator personnel at battalions. Another form of embedded training is a set of 2 tapes that provide 18 scenarios for Battalion level team training and 2 tapes that provide 19 scenerios for Division level team training. These scenarios train three-man teams consisting of computer operator, FDC officer and a VFMED operator. Inputs from FOs, guns, etc. are simulated in these scenarios which run from one to three hours. Job performance lessons and a set of programmed instruction texts have also been developed to be used both with and without the equipment (USAFAS, Undated a; Bray, 1985; Dies, 1985; Suzuki, 1985).

The team scenarios exercise only the TACFIRE computer teams of the DIVARTY TOC or Battalion Fire Direction Center. No training in system operation occurs for remote device operators such as the VFMED, FIST DMD, DMD, BCS or GDUS. The only time these operators are trained is during FTXs, ARTEPs, etc. (Bray, 1985; Dies, 1985; Suzuki, 1985).

There is very little use of the embedded training or other parts of the exportable training package. The Training Support Branch has recommended 16 to 20 hours of training per week for each operator (Suzuki, 1985). We talked to a few operators and each reported little or no unit training other than major FTXs (Bray, 1985; Hawking, 1985). A June 1985 report of a US Army TRADOC Systems Analysis Activity study on institutional and unit TACFIRE training effectiveness indicated that exportable TACFIRE training is little used in most artillery units (TRASANA, 1985). Those (few?) units which maintain high computer operator proficiency apparently do it by conducting frequent exercises in a "TACFIRE ark" configuration involving much or all of their equipment and personnel. There is no extensive use of the CAI, team training scenarios, job performance lessons or programmed texts (Hawking, 1985). Tables D-3, D-4 and D-5 summarize pertinent results of the study.

UNIT TRAINING COSTS

Unit training costs on TACFIRE equipment are difficult to ascertain because no specific cost accounting is maintained at the unit level. However, associated training costs are the expense of electrical generation equipment, TACFIRE equipment maintenance costs due to RAM effects and damaged training tape replacement costs. No specific cost can be estimated at this time; however, training costs are not seen as significant.

Table D-3

Extension Training Materials Used by TACFIRE Operators (N = 183)

Extension Training Materials (ETM)	Have Used ETM (Numbers) Present Unit	Previous Unit
Programmed Texts	49 (27%)	22 (12%)
Job Performance Lessons	34 (19%)	15 (8%)
Computer Aided Instruction	27 (15%)	16 (9%)
Team Training Tapes	22 (12%)	20 (11%)
Average:	33 (18%)	18 (10%)

(TRASANA, 1985)

Table D-4

Unit Training of TACFIRE Operators (N = 183)

Hours Per Week	Number of Soldiers Individual Training	Unit Training
0	101 (55.2%)	89 (48.6%)
1-5	48 (26.2%)	46 (25.1%)
6-10	24 (13.1%)	33 (18%)
> 10	10 (5.4%)	15 (8.2%)
Total:	183 (99.9%)	183 (99.9%)

(TRASANA, 1985)

Table D-5

Frequency of TACFIRE Hands-on-Operation

Frequency	Number of Responses
Daily	18 (9.8%)
Weekly	39 (21.3%)
Monthly	11 (6.0%)
Only During a Field Exercise	100 (54.6%)
Other	15 (8.2%)
Total:	183 (99.9%)

(TRASANA, 1985)

SHIFT FROM TRAINING TO OPERATIONS MODE

Since most effective unit training occurs in FTXs, the system is already in the operational mode when training occurs. When the team training scenarios are used, less than 15 minutes is required to set up the system (Bray, 1985; Suzuki, 1985). About the same amount of time would be required to return to the operational mode. The individual DIVARTY CAI lessons would require similar set-up and take-down times (Wu, 1985).

TRAINING MANAGEMENT

There does not appear to be much in the way of training management at the unit. If daily or weekly training is scheduled by the Battalion S3, it seldom occurs. Attempts are made to "cram" prior to an ARTEP but there is too much for TACFIRE operators to learn using this "conventional" Army training technique (Hawking, 1985; TRASANA, 1985).

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

The equipment is potentially available during normal duty hours and at other times. However, equipment operation requires starting of generators, expenditure of fuel and additional personnel other than the computer operators and teams to be trained. Personnel are frequently required to perform other duties that conflict with training. When personnel are trained on the equipment, key officer and NCO personnel are often absent. This weakens training because the leaders are not trained and their inputs to training are not available to the soldiers. The absence also results in a lack of motivation for training (Bray, 1985; Dies, 1985; Hawking, 1985; TRASANA, 1985).

ADEQUACY OF TRAINING SYSTEM

Every indication is that operational readiness problems exist with TACFIRE. This is not true of all units, however. Where units are highly successful in ARTEPs or at the National Training Center at Ft. Irwin, it is apparently because they do emphasize training of computer operators and other personnel associated with the TACFIRE computer through extensive FTXs or, in some instances, extensive Motor Pool training (Hawking, 1985).

IMPEDIMENTS TO TRAINING

Lack of command emphasis on training appears to be a problem. This results from a tendency to blame the TACFIRE system for operational problems and an associated lack of awareness of the potential of TACFIRE operator training for overcoming the real problems that do exist in the TACFIRE hardware and software.

Training software is no more user friendly than the operational software, so that the normal operator will find present training just as burdensome as actual operation.

Computer assisted instruction (CAI) lessons are not available for functions required at the Battalion level. The only embedded training available at this level is the set of team training tapes and paper training tools. No ET for individual task training is available.

Command confusion may exist over the training received by the entry level 13C10 TACFIRE Operator. This soldier receives no training on the TACFIRE computer, yet he is labeled and identified as a TACFIRE Operations Specialist. This confusion may limit the amount of training that a commander perceives his assigned 13C10s as needing.

SUMMARY

The development of the Tactical Fire Direction System (TACFIRE) began in 1966, and the first systems were fielded in 1980. They were already outdated systems when fielded and their condition has not improved. The Advanced Field Artillery Tactical Data System (AFATDS) is scheduled to replace TACFIRE by 1990.

Embedded training (ET) for TACFIRE consists of computer assisted instruction (CAI) lessons and team training tapes.

The CAI lessons were developed with the PLANIT language for institutional individualized instruction. They were subsequently incorporated into the exportable training material (ETM) supplied for unit training. These are structured lessons aimed primarily at the novice TACFIRE student. They do provide feedback and recordkeeping capability. Present ETM lessons are limited to TACFIRE operations specific to the Division Artillery computer. No CAI

lessons are presently being exported to Field Artillery Battalions for individual instruction.

The team training tapes in the ETM provided to battalion and division units provide a collective training capability. This training capability is limited in effect by an inability to collectively assemble all team members so team training can be conducted. The team training tapes consist of message formats that must be correctly completed and transmitted between computer operator and Tactical Operations Center (TOC) VFMED operators. Operators must still utilize their manuals to determine correct entries for each format utilized in the scenario. No individual feedback is provided and only general feedback on team operations is given. No recordkeeping capability exists.

Operational software is extremely difficult to operate. There are 160 individual message formats with 411 TACFIRE specific mnemonics required to operate the computer and VFMED. None of these formats provide any imbedded cues, prompts or other aids to help the operator determine required or optional entries. This places a tremendous memory burden on the operator unless he utilizes the reference manual, thus slowing down his response time. The training requirement could be dramatically reduced if the operational software were modified to incorporate embedded cues, prompts or other aids in making appropriate entries. A menu format could be utilized rather than the present full message format display which is almost overwhelming in its cue presentation. A menu format would also reduce the requirement to memorize 411 TACFIRE abbreviations presently being used.

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APPENDIX E

ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM (AFATDS)

CONTENTS

APPENDIX E

ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM (AFATDS)

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Field Artillery Tactical Fire Direction System

2. System Components:

The AFATDS system will consist of several linked microprocessors, each having a specialized Field Artillery command and control function. These microprocessors will be small and lightweight ("suitcase" variety) with expanded memory capability. As with TACFIRE, the component elements of the AFATDS Computer will vary in quantity depending upon which functional level it controls - Corps, Division Brigade or Battalion (Marczak, 1985). One key component at each node will be the AFATDS Fire Support Terminal (U.S. Army Field Artillery School [USAFAS], 1983).

AFATDS will receive inputs from and control many of the same remote devices and fielded systems that are currently handled by TACFIRE such as the Digital Message Device (DMD), Fire Support Team DMD (FIST-DMD) and the Battery Computer System (BCS) (Marczak, 1985). Descriptions of these related systems are included in the TACFIRE System description in this report. The related developmental systems described in the description of TACFIRE will also be related to the AFATDS system.

3. Prime Mover:

The AFATDS system components for a single "node" will be transportable in a single vehicle. A tracked vehicle similar to an M-113 is depicted in the Individual and Collective Training Program (ICTP) (USAFAS, 1985).

MISSION

To provide improved automated command, control and coordination for more efficient management of the fire support resources of a Field Artillery element of Corps, Division, or Brigade size. AFATDS will process fire support and fire support coordination data requirements for target acquisition, indirect fire weapons, armed aircraft and other lethal and non-lethal means in support of battle plans. To achieve this mission, AFATDS, like the TACFIRE System it replaces, will provide an integrated system of fire control complexes that use digital computers, remote devices, graphic display units, control consoles and other equipment combinations appropriate to the function performed (USAFAS, 1985).

The AFATDS fire support command, control and coordination system mission is divided into five operational categories: (1) fire support control and coordination; (2) target generation and processing; (3) FA tactical operations; (4) support and sustainment; and, (5) FA technical fire direction. The first two categories support total-force fire-support requirements while the second two deal with the FA portion of the fire support assets. The final category (FA technical fire direction) will occur only for the cannon delivery systems. Technical fire direction for other delivery systems (MLRS, Lance, Pershing, etc.) will be accomplished at the appropriate fire unit (USAFAS, 1983).

HISTORY OF SYSTEM ACQUISITION

The AFATDS will replace the total TACFIRE System in three steps. Step one is the fielding of the Communications Control System in the 1990-1991 timeframe (we recently learned from TSM-AFATDS that this step may be eliminated since TACFIRE already may have adequate communication control). Step two consists of AFATDS battalion and brigade software development, culminating in a test bed to validate that software. This will be followed by systems integration, full scale systems development, development of division and corps software, DT/OT II (IOC 1990) and production and deployment beginning in FY 1992. Step three will be partially concurrent with step two and will consist of preplanned product improvements (P^3I) to AFATDS (USAFAS, 1985).

The AFATDS Task and Objective Schedule (from the March 1985 ICTP) is included in Table E-1.

PERSONNEL AND KEY JOB TASKS

The following are proposed AFATDS MOSs and major duties (USAFAS, 1985):

13C - Operate AFATDS computer and peripherals and perform organizational maintenance.

34Y - Repair AFATDS System.

One consideration for AFATDS Tactical Operations Center Officer job design and resultant training suggested by MAJ Hawking (1985) is that these personnel be trained to input their decision data and supporting communications directly to the system so that they can operate AFATDS without operator mediation. Commanders at TACFIRE units currently are greatly frustrated by their dependence on TACFIRE computer operators, many of whom are not totally aware of the TACFIRE capabilities (Hawking, 1985).

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

AFATDS will use intelligent terminals, electronic displays and line printers that will maximize use of the Military Computer Family development. Operators will interact with the system from the Fire Support Terminal which

Table E-1

AFATDS Task and Objective Schedule

Task/Objective	UASFAS dates
OT II:	1Q 88
ICTP:	4Q 84
NETP(Semi-annual May & Oct)	on hand
TQQPRI:	2Q 83
FQQPRI:	3Q 87
FBOIP	3Q 87
NETT:	4Q 90-2Q 95
FUE:	4Q 90
IOC:	4Q 91
Training Devices	TED
Facilities, Ranges, Real Property:	TBD
ARTEP (Coord date):	FY 92
CTEA:	TBD
COEA:	TBD
ITP: for MOSs 13C, 13F, 34L and 34Y	FY 87
and for SC13	FY 87

will have an interactive display entry panel and a keyboard unit. A high speed 1200 LPM, 80 column, noiseless printer will be a peripheral item at nodes of AFATDS which require file copies of data, messages and graphs. A large CRT display (approximately one meter square) will be a peripheral item at nodes that require large displays of map data (USAFAS, 1983).

COMPUTER CAPABILITIES

Although physically compact, AFATDS will have a large computer (Military Computer Family--AN/UYK-49) with a memory capacity in the 16-20 Megabyte range. There is anticipated to be a bubble-cassette input device which would allow rapid input of programs, large data bases, training software/courseware systems, etc. (USAFAS, 1983; Marczak, 1985).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

Given the large computer included with the system and given that system displays will provide all (or nearly all) of the information operators and other personnel receive during combat, full simulation should be possible with appropriate software developments and with minimal need for hardware "strap-ons." The proposed embedded training for the system should be designed to capitalize on this computer capability.

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

Given the sophisticated computer and peripherals planned for the system, the capacity to provide accurate performance feedback should be large. The embedded training/testing system should include the most sophisticated features tableavailable such as adaptive testing, networking for simultaneous training and/or testing of multiple personnel or multiple teams, etc. However, current planning is not extensive enough to know whether this will occur or not.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

The large training requirements and training problems associated with TACFIRE have been a major consideration in the design of AFATDS. Institutional training, training devices and embedded training are all included in system planning. Only the institutional training has been planned to any major extent, however.

EXISTING/PROPOSED INSTITUTIONAL TRAINING

The AFATDS courses planned as resident courses at the US Army Field Artillery School for AFATDS operators and maintainers are listed in Table E-2 (USAFAS, 1985).

Institutional training at USAFAS and will focus on qualifying operators to be proficient in their assigned duty position while utilizing AFATDS equipment (USAFAS, 1985).

Table E-2

Proposed AFATDS Resident Courses

COURSE	LENGTH	MOS/ASI
TACFIRE/AFATDS Operations Specialist	5 weeks 5 days	13C10
AFATDS NCO Tactical Operations BTC (New Course)	5 weeks	13C30
AFATDS FA Cannon Advanced (FACA)	5 weeks	13C40
AFATDS FA Fire Support Control & Coordination (New ASI Course)	5 weeks	13F10
AFATDS FA Fire Support Control & Coordination BTC (New Course)	5 weeks	13F30
FA Tactical Fire Direction System Repairer	22 weeks	34Y10

EXISTING/PROPOSED UNIT TRAINING

Embedded training software in the form of a "plug-in" cartridge is currently planned for the AFATDS Fire Support Terminal. This will be further tested in the AFATDS Concept Evaluation. This embedded training will be provided for each AFATDS set for unit sustainment training (USAFAS, 1985). Unfortunately, these minimal statements apparently represent all of the elaboration of the future embedded training system and this failure to plan may limit the capabilities of the future system.

UNIT TRAINING COSTS

AFATDS will have smaller power requirements than AFATDS and is anticipated to use the generator of the vehicle in which it is mounted (Marczak, 1985). Fuel costs and personnel costs for unit training with an embedded training system should be low.

SHIFT FROM TRAINING TO OPERATIONS MODE

Fast program-entry devices and a lack of need for strap-on displays/controls in order to present/respond to simulated combat stimuli (USAFAS,

1983) should make transitions from and to training rapid and similar to those for Aquila and Patriot which are five minutes or less.

TRAINING MANAGEMENT

AFATDS distributed processing capability and distributed data bases (Marczak, 1985) will allow for enhanced training management if planners consider this possibility in training system design.

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

TACFIRE may be an appropriate model to use to predict the availability of equipment and troops for training. Unfortunately, despite a larger requirement for sustainment training with TACFIRE than with AFATDS, the record does not indicate adequate embedded training or other sustainment training for TACFIRE (Hawking, 1985).

ADEQUACY OF TRAINING SYSTEM

The training system is too poorly defined at this point to make any predictions. Hopefully, the capacity of AFATDS for embedded training will be exploited and a highly adequate embedded training system will be developed.

IMPEDIMENTS TO TRAINING

One can only project at this point what impediments to training may exist for this developing system. Shortsightedness in development of unit training packages appears to be a danger, however. The goal of AFATDS to greatly reduce training time and needs compared to TACFIRE (Marczak, 1985), may lead developers to fail to provide the necessary unit training hardware, software and courseware that will inevitably be needed for effective sustainment training, regardless of the amount of automation/cueing/etc. included in the development of the operational hardware and software.

SUMMARY

The AFATDS system will begin to replace TACFIRE in the 1990s. It will perform the TACFIRE mission of automating selected command and control functions to provide more efficient management of the fire support resources of Field Artillery force elements of different sizes plus a number of additional functions. It is proposed to do these with much more compact and user-friendly computers and associated equipment. One key goal for AFATDS is to reduce the need for training, and this undoubtedly is a reaction to the huge training requirements for TACFIRE operators and other TACFIRE personnel.

Embedded training is included in specifications for AFATDS development. However, specific features of this embedded training system have not been described. Computer capacity, peripheral devices and displays proposed for AFATDS would appear to be adequate to support the most sophisticated embedded training system imaginable. For example, there is discussion of the inclusion of as much as 16 to 20 megabytes of RAM. Peripheral input devices may include bubble memory cassettes (presumably with capacities also in the multi-megabyte range) which could be used to input embedded-training courseware to the system. Large CRT displays would eliminate needs for slow and inflexible plotters and this dynamic display capability should easily allow training of both operator skills and operator knowledges.

The huge CPU capacity, memory capacity and data/program input capacity would even allow non-system skills and knowledges to be trained. With proper equipment design, "networking" could occur and instruction could be sent to terminals located away from the AFATDS vehicle to assist with qualification, sustainment training and cross-training of large numbers of AFATDS personnel and other Field Artillery personnel. This networking suggestion emanates from our learning from CPT Signorelli of the Multiple Launch Rocket System (MLRS) training branch that the embedded-training system on the MLRS was insufficient to provide training to all of the MLRS personnel needing it for such things as skills qualification test (SQT) preparation. Additional terminals affixed to the large AFATDS computer system could possibly help solve this problem for AFATDS, HIP and MLRS.

Additional expenditure of effort in the design of these embedded training packages at these early stages of system development could provide large payoffs in effective unit training. A specific additional effort to achieve this for HIP has been proposed and will occur shortly. A similar effort could enhance the embedded training for AFATDS. Unfortunately, there do not appear to be adequate funds or consideration being given to maximize this AFATDS embedded training opportunity.

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APPENDIX F

AQUILA REMOTELY PILOTED VEHICLE (RPV) SYSTEM

CONTENTS

CONTENTS (continued)

APPENDIX F

AQUILA REMOTELY PILOTED VEHICLE (RPV) SYSTEM

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Remotely Piloted Vehicle

2. System Components and Functions:

The Aquila RPV is an unpiloted pusher-prop aircraft that is six feet in length with a wingspan of 13 feet. This aircraft is equipped with a television camera and a laser device for range finding and laser designation of targets for precision guided munitions. Forward looking infrared radar (FLIR) will become an optional payload to the TV about a year after fielding of Aquila units. A remote ground terminal (RGT) consists of a trailer-mounted dish antenna and associated electronics. It receives data from the air vehicle in the form of flight status information and payload sensor data and video. The RGT transmits both guidance commands and mission payload activation commands to the air vehicle. A truck-mounted, compressed-air catapult is used to launch the aircraft and it is captured by a recovery net that is raised and lowered from the rear of another truck (US Army Field Artillery School [USAFAS], 1984a, 1985).

The operational control center of the Aquila System is the ground control station (GCS) which is manned by a Mission Commander, an Air Vehicle Operator (AVO), and a Mission Payload Operator (MPO) who operates the sensor package. The sensor package optics are stabilized so that targets can remain fixed in the fields of the TV camera and the laser that is bore-sighted with the camera. Good TV pictures and steady laser designation occur even during the preprogrammable and violent evasive maneuvers of the vehicle ("jinking") which can be introduced to reduce the chances of the RPV being shot down. Video recording equipment exists that can record and play back one hour of video imagery for later evaluation or other use (e.g., training operators). A microprocessor in the GCS is used: 1) to control the autopilot; and, 2) for surveillance and information processing (USAFAS, 1985).

An RPV Battery will consist of five GCSs and associated launch, recovery, tracking, etc., subsystems. Two rear-located GCSs known as Central Launch and Recovery Sections (CLRSs) will launch the Aquila RPVs and hand them off to one of three Forward GCSs which will conduct actual missions. Following the mission, the RPV will be handed back to a CLRS for recovery (USAFAS, 1985).

3. Prime Mover:

Approximately 20 5-ton trucks and nine trailers are required to transport the Battery with its five GCSs: tracking, launch, recovery and air vehicle handler subsystems; and air vehicles (USAFAS, 1985).

MISSION

Missions of the Aquila RPV are target acquisition (coordinate and range finding), artillery adjustment, laser target designation for precision guided munitions, aerial reconnaissance and damage assessment. Aerial reconnaissance will occur for the division/brigade out to 20 km forward of the front line of troops (FLOT) and will exploit the range capability of the Multiple Launch Rocket System. The initial daylight system will be improved shortly after fielding when a FLIR sensor becomes available to perform these missions at night and in adverse weather (USAFAS, 1984a).

HISTORY OF SYSTEM ACQUISITION

The original required operational capability (ROC) for this RPV system was developed in the mid 1970s (Bradford, 1985). Aquila system developers demonstrated much foresight in recognizing the need for an embedded unit trainer of operator tasks at or shortly after the conception of Aquila. An embedded training requirement was included in the original ROC (USAFAS, 1984a). Lockheed Missiles & Space Co. was contracted on 31 August 1979 for full scale engineering development of an RPV System. The first flight of the system occurred in the spring of 1982.

The current Training Interface Unit (TIU) was not the first embedded trainer that the contractor provided. However, an earlier embedded trainer was far too large to be used at the unit and the imagery the computer generated to simulate terrain and targets was described by Aquila training system developers as merely "stick figures" that were inadequate simulations of Aquila RPV video. Following this failure, Lockheed subcontracted the development of the embedded trainer to Redifusion and Silicon Graphics. The resultant TIU far exceeded the (lowered?) expectations of the system developers despite the fact that it was developed in only a few months (Bradford, 1985; Duitsman, 1985).

Development Testing is occurring at Ft. Huachuca and Operational Testing II is occurring at Ft. Sill during the Summer of 1985. In FY 85, the Army asked Congress to appropriate $144.5 million to acquire 32 aircraft and nine GCSs, although a production decision could not be made until late in the summer of 1985 at the earliest. Senate committees requested that most of this be deferred and it probably will be. The requested level of FY 85 R&D funding was $103.1 million (Ludvigsen, 1984).

PERSONNEL AND KEY JOB TASKS

Fielding of the Aquila will result in the creation of new Military Occupational Specialties and Additional Skill Identifiers consisting primarily of the 13TXX - RPV Operator, 13TXXP9 - RPV Operator/Mechanic, and 212A - RPV Technician (USAFAS, 1985). These are listed with major tasks in Table F-1.

Table F-1

Aquila MOSs and Major Tasks

MOS	Title	Duty/Tasks
13T	Air Vehicle Operator	Program planned missions into computer Acquire/hand-off vehicle from CLRS Input ad hoc waypoint, speed and altitude changes to air vehicle Adjust flight for point surveillance or target laser designation Initiate "jinking" to avoid shoot-down
13T	Military Payload Operator	Survey video (FLIR) for targets Obtain range and coordinates of targets Laser-designate targets for PGMs Measure needed artillery corrections Assess damage from artillery and other munitions
13T	Recovery Personnel	Hoist recovery barrier Extract air vehicle from net
13T	Launcher Personnel	Deploy folded hydraulic catapult Mount aircraft on launch rail Test vehicle systems
212A	RPV Technician (Mission Commander)	Plan missions Survey video for targets Transmit/receive digital messages via TACFIRE

A total of sixty-two spaces (including RPV-peculiar supervisory personnel) are required in each battery for RPV operations. A breakdown of battery personnel by MOS, grade, position title, and section is shown in Table F-2 (USAFAS, 1985).

The twenty-two personnel required for both RPV peculiar and common ground support equipment maintenance in each battery are listed in Table F-3 (USAFAS, 1985).

Table F-2

Battery and Force Personnel for Aquila

Position Title	Grade	MOS	HQ	CLRS(X2)	FCS(X3)	Btry	Force
Battery Commander	CPT	13D	1			1	13
Executive Officer	LT	13D	1			1	13
RPV Technician	WO	212A		1	1	5	65
First Sergeant	E8	13W5M	1			1	13
Operations Specialist	E3	13T10	1			1	13
RPV Section Chief	E7	13T40		1	1	5	65
RPV Team Leader	E6	13T30		2	1	7	91
Air Vehicle Leader	E5	13T20		1		2	26
	E4	13T10		1	1	5	65
	E3	13T10		1	1	5	65
Payload Operator	E5	13T20			1	3	39
	E4	13T10		2	2	10	130
Launch/Recovery Tm Ch	E5	13T20		1		2	26
RPV Crewman	E4	13T10		1		2	26
	E3	13T10		6		12	156
Per Section			4	17	8	62	
Total			4	34	24	62	806

Table F-3

Aquila Ground Support Personnel Requirements

Position Title	Gde	MOS	RPV Maint	GS Maint	CLRS(X2)	FCS(X3)	Btry	Force
RPV Maint Team Chief	E6	13T30P9	1				1	13
Motor Sergeant	E6	63B30		1			1	13
Wheel Vehicle Mechanic	E5	63B20		1			1	13
	E4	63B10		2			2	26
	E3	63B10		2			2	26
RPV Operator/Mechanic	E5	13T20P9			1	1	5	65
	E4	13T10P9	3				3	39
Pwr Gen Equip Mechanic	E4	52D10			1	1	5	65
Utility Equip Repairer	E4	52C10		1			1	13
Tactical Comm Sys Mech	E4	31V10		1			1	13
Per Section			4	8	2	2		
Total			4	8	4	6	22	286

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

The major information displays are three 13" high-resolution CRT monitors in the engagement control station with one each for the Air Vehicle Operator, the Mission Payload Operator and Mission Commander. Video from the Aquila sensor package is displayed on all scopes. Superimposed graphics provide information related to target coordinates, Aquila flight parameters, etc; and this digital information varies from one position to another. In addition, there is a plotting board which is visible to all three positions (Smith, 1985; USAFAS, 1985).

The crew interacts with the system via numerous pushbuttons, a joystick (MPO), dials (AVO), etc. Each position has a light pen, but controls generally differ for each position as needed to perform the different functions. The Mission Commander also has a digital message device that allows digital communication with the TACFIRE computer and Battery Computer System (Smith, 1985; USAFAS, 1985).

From the standpoint of the development of embedded training, one key factor is that all information is provided by the system displays. There is no direct view or optical view of the enemy that presents a difficult simulation problem such as that on the Sergeant York (Purifoy, Roth, Sullivan, & Bogner, 1985); only video need be simulated. Another factor that facilitates embedded training is that all interaction in the operational mode is with the system computer which controls the Aquila autopilot, pointing of the sensor package, etc. As with displays, no special interface is required during training to interact with the system with the exception of the hand-held key pad that is used with the Training Interface Unit to input data commands to the GCS CPU to initiate artillery burst offsets, GCS system faults and air vehicle operation faults (Smith, 1985).

Currently, a plotter gives information about the current Aquila position and its flight path (USAFAS, 1985). Some discussion has occurred about replacing this plotter with a large CRT like that at Division Artillery (DIVARTY) for TACFIRE (Bradford, 1985; Duitsman, 1985). We echo this suggestion and would propose that it also provide color map graphics of the surveillance area such as those provided by the Harris Digital Map Generator. Superimposed on this digital map could be the programmed route of the RPV, a symbol indicating the present position and direction of the RPV, and a four-sided figure that accurately depicts the terrain displayed on the CRT originating from the sensor package. The figure would include a cross-hair at the range-finder/laser-designator "center" of the video camera picture. This would help the GCS crew to maintain their bearings during flight and sensor package maneuvers. We were informed by Ft. Sill personnel that this currently is a problem, particularly for MPOs (Bradford, 1985).

It would also be helpful to put all terrain in red that is higher in altitude than the RPV. This could prevent crashes and facilitate low-altitude flights of the RPV. All areas behind hills between the RPV and the Remote Ground Terminal which would not allow line-of-sight transmission could also be indicated in red (or some other color). As the air vehicle increased its altitude, less terrain would be restricted in either manner.

COMPUTER CAPABILITIES

The Aquila GCS CPU currently is a Norden model 11-34/M 16-bit word computer with 64K of nonvolatile memory and with an automatic restart capability. In addition, there is a GCS interface unit which consists of an eight-bit microprocessor, 16K PROM, and 8K of RAM. This unit provides the interface between the CPU, telemetry unit interface, operators' control and display assemblies, video displays, recovery guidance aid and Training Interface Unit. The telemetry unit interface reformats the serial data from the telemetry unit to a parallel format for the CPU (USAFAS, 1985).

A design change is currently being considered to expand memory capability and throughput reserve of the GCS main computer. This probable change will provide 512K of RAM and will substitute a 1-megabyte cassette bubble memory unit for the current hard-disk unit (Phone conversation with Mr. John Brown, Software Branch of the Project Manager's Office, personal communication, 15 August 1985).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

The prime equipment lacks sufficient computer memory to store a digital landscape with targets and a "strap-on" Training Interface Unit (TIU) provides this capability. The GCS CPU does include a flight simulator known as the flight dynamics simulation (FDS) computer program. This flight simulator was originally included to try out programmed Aquila flights prior to launch. This flight simulator now is only used to provide dynamic data to the TIU to enable the console video displays to simulate line-of-sight perspectives, cursor position, auto track views and targets (USAFAS, 1985; Phone conversation with Mr. John Brown, Software Branch of the Project Manager's Office, personal communication, 15 August 1985). The TIU also permits programmed flight plan and console operator inputs to drive nonvideo displays (USAFAS, 1985).

The major components of the TIU are an Interactive Imagery Simulator (IIS) and a Portable Data Entry Terminal (PDET). The IIS receives inputs from the FDS computer program and generates signals for a computer-generated video picture (USAFAS, 1985, p. E-12). This results in adequate and useful, though <u>not</u> high fidelity, simulations of the actual terrain/target video provided by the television camera during Aquila flights over terrain and targets. A more powerful computer is to be added to the system and there was some concern among TSM and training personnel that the TIU would not be compatible with it. According to Mr. John Brown (personal communication, 15 August 1985), of the Software Branch of the PM-RPV office in St. Louis, the flight dynamics simulation computer program will need to be added to the new computer software to make the TIU compatible with the new computer.

A VCR exists in the GCS for recording and replaying up to one hour of GCS audio and Mission Commander Console video for mission analyses (USAFAS, 1985). It would appear that the video from Aquila missions during major FTXs should be

routinely recorded since such videos would have much training value for target identification if viewed by Aquila GCS operators. Recorded FLIR video would appear to provide much-needed training of target identification when the FLIR sensor package first becomes available. Audio added to these videos could enhance their training potential by pointing out significant targets. The actual conversations of GCS personnel during recording of Aquila sensor video during these FTXs would probably serve this function.

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

Air Vehicle Operators obtain feedback on performance during TIU use to the extent that they observe the terrain changes consonant with their programmed and ad hoc flights. Mission Payload Operators are given similar feedback when terrain/target changes are observed consonant with slewing of the sensor package or with changes of the lens or of video magnification. Mission Payload Operators also receive performance feedback during training with the TIU when they are successful or unsuccessful in locking the target tracker on the various targets (Smith, 1985).

Currently, a hand-held programmable data entry device (PDET) is used by the "instructor" to input "faults" into the scenario and also to display artillery bursts on the target or at selected distances from the target. Thus, conditions can be simulated such as a loss of radio contact, low aircraft fuel, loss of target track, etc. Appropriate AVO and/or MPO actions solve these problems and this is another form of operator feedback provided by the system (Smith, 1985).

We learned from TSM personnel that more operator feedback and more automatic inclusion of mission problems were originally planned for the TIU (Duitsman, 1985). Hopefully, these important goals will continue to influence TIU development. The computer and other components of the Aquila System would allow much more feedback (given appropriate software), especially when a larger computer and rapid-access bubble-memory storage for programs become available.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

Currently, training of military personnel to be "test players" for Operational Test II is being conducted by the Target Acquisition Division at USAFAS. These courses and other training procedures will be modified as necessary and will become the basis for the training to be developed for deployment and sustainment of units (Bradford, 1985).

During the production and deployment phase, individual and collective (packet) training will take place at the USAFAS in order to field fully-trained Aquila RPV units. This training will consist of formal classroom instruction, lab/hardstand exercises, exercises utilizing the institutional GCS simulator and the USAFAS-based TIUs, crew drill and actual flight to ARTEP standards. Training for initial fielding will be a combination of individual, collective (packet) and New Equipment Training Team (NETT) and this training

will begin nine months prior to fielding. Twenty-five weeks of individual training and seven weeks of collective unit training will culminate with the administration of an ARTEP prior to deployment. NETT training will be from 4-6 weeks in duration consisting of DS/GS maintenance requirements instruction (USAFAS, 1984a, 1985).

During the sustainment phase, USAFAS will conduct all individual Skill Level One training for RPV operators and for organizational maintenance of the RPV. Unit/collective training will be accomplished through a combination of actual Aquila RPV flights, crew drills using actual hardware, plus training with the TIU and Inert Air Vehicle to reduce needs for actual flight and handling of actual aircraft (USAFAS, 1984a).

EXISTING/PROPOSED INSTITUTIONAL TRAINING

The projected USAFAS courses in support of the Aquila RPV are listed below as described in the recent O&O Plan (USAFAS, 1985).

1. 13TXX RPV Operator

This will be a 19-week MOS producing course that covers system-peculiar training in the functional areas of the GCS, modular integrated communications and navigation system, air vehicle, launcher and recovery operations. Soldiers will receive instruction on basic tactical map reading, gunnery terms and application, meteorological requirements for laser designation, ECM and threat, artillery survey techniques, digital message device, communications, vehicle identification, airspace management, vehicle maintenance and operations.

2. 13TXXP9 Operator/Mechanic

This Additional Skill Identifier (ASI) producing course will be approximately nine weeks of instruction in addition to the 16-week 13TXX MOS producing course. Instruction is oriented to unit-level maintenance of RPV peculiar system equipment.

3. Basic Technical Course (BTC)

A 13T track of six to eight weeks in length will be required to support MOS skill levels 2 and 3.

4. Warrant Officer Course

The 212A RPV Technician course will be a new twenty-eight week MOS producing course for warrant officers consisting of 25 weeks of RPV equipment, operation and employment instruction and three weeks of DS/GS maintenance instruction.

Key portions of the 13T RPV Operator course and the Warrant Officer Course will use the RPV institutional trainer that will simulate GCS operator tasks using a dual videodisc system to generate video for the operator stations. This will be a 42-station procedural trainer capable of

simultaneously training 15 air vehicle operators, 15 mission payload operators and four 3-man GCS crews. It will be housed in a fixed facility at Fort Sill, Oklahoma, and will facilitate initial operator skills acquisition and reduce the number of instructors and actual equipment required for training (Neil, 1985; USAFAS, 1984a).

EXISTING/PROPOSED UNIT TRAINING

Unit Training will be accomplished through a combination of actual Aquila RPV flights, crew drills using actual hardware, plus training with the TIU and the Inert Air Vehicle (IAV) to reduce needs for actual flight and handling of actual aircraft. The crew drill can be accomplished in a garrison environment, providing a nominal 300 meter X 300 meter cleared area is available to allow realistic dispersal of section equipment. Each RPV Battery will have two of the removable TIUs and each RPV section will have two IAVs for training. Therefore, each section will be able to train collectively as a unit at least two days per week. Preliminary plans state that each RPV section will conduct 42 actual flights per year (two two-hour flights per month, and two three-day FTXs per year - each having three two-hour flights per day). These activity rates will be impacted by such considerations as proximity to, and availability of, adequate range facilities which can support flight. Descriptions follow of the embedded training equipment and software that either have already been developed to support unit training, will be developed in the future for this purpose, or, in the case of the strap-on mission payload, is being considered for such development (USAFAS, 1984a).

1. Training Interface Unit (TIU)

The TIU is a small, portable simulator that interfaces with the GCS computer and operator consoles. It simulates all phases of an RPV mission to include air vehicle flight control, data displays and interpretation without the requirement to conduct actual flights of the air vehicle. The simulator itself provides computer-generated imagery to the TV monitors for display of such parameters as mission payload line of sight perspectives, autotrack views, cursor pointing, terrain features, man-made objects (including moving and stationary targets) and artillery burst simulation for artillery adjustment training. The simulator is programmable by unit personnel and can be used to insert fault symptoms for maintenance training. The TIU will be issued to the battery and used in garrison and field training (USAFAS, 1985).

The TIU provides five training scenarios each involving computer generated imagery (CGI) of a 25 km. X 25 km. Ft. Hood area and each including about 70 CGI stationary threat vehicle targets and two or three CGI moving threat vehicles. This is a "strap-on" device the size of a suitcase that fits in a corner of the GCS van. The hardware contains banks of computer memory which store the digitalized terrain and targets. For storage and transportation purposes, the hardware is placed in a ruggedized metal case; the combined weight is 125 pounds. The TIU takes advantage of the flight simulator that already exists in the Aquila operational software. This flight simulator

is used during embedded training to maneuver over the geography and targets provided by the strap-on TIU (Lockheed, undated; 1985).

At this writing, Aquila is only at the operational test stage, but the value of this TIU embedded trainer has already been demonstrated. During our late-July 1985 visit to Ft. Sill, the Aquila was "grounded" because of a crash of an Aquila at Fort Huachuca (during Development Testing) a few days before. Thanks to the TIU, meaningful training of the air vehicle operator (AVO), the mission payload operator (MPO) and the Mission Commander was still occurring at Ft. Sill, despite the fact that trainees were unable to launch, fly and catch Aquila RPVs. The embedded training of these personnel with the TIU should prevent delays in the upcoming Operational Test II for which military personnel are currently being trained (Smith, 1985).

2. Inert Air Vehicle

The inert air vehicle is a device comprised of non-functional internal components that enables collective training in air vehicle assembly, disassembly, maintenance operations and launch and recovery operations. Fault isolation for the air vehicle components will be simulated using the maintenance shelter air vehicle fault isolator (AVFI). Launch and recovery operations can be conducted in a 50 meter by 50 meter area on an earthen 14 degree slope ramp using the launcher and recovery subsystems and a pitch and catch technique. Each RPV battery will have two inert air vehicles (USAFAS, 1985).

3. Air Vehicle Fault Isolator (AVFI)

The AVFI is a piece of automatic test equipment located in the maintenance shelter that is used to test the air vehicle and the mission payload. The AVFI has a built-in training guide that permits simulation of faults (USAFAS, 1985).

4. Mission Payload Eye Safe Laser

Although not specifically a training aid or device, each mission payload subsystem has a built-in eye safe laser feature. This capability allows the operation of the laser in field training exercises without injury to vehicles and personnel. In the eye safe mode and with cooperative targets (retro-reflector equipped), laser rangefinding is provided but not scoreable laser designation (USAFAS, 1985).

5. Strap-on Mission Payload

A strap-on mission payload is being considered for development that can be placed on a helicopter or other manned military aircraft. Another name for this device is the Surrogate Aquila Training System or SATS. This device will permit the conduct of RPV missions without the use of an actual air vehicle. This substitution may be required because of a lack of suitable ranges, safety restrictions and airspace limitations or constraints in CONUS and overseas areas. The strap-on payload would be used in major military exercises for the training of commanders and staffs on target identification and designation as

well as the RPV battery and operational sections. In particular, the video provided by this helicopter-mounted camera would be useful for training MPOs and Mission Commanders in target identification and designation. The helicopter would fly a preset route as the Aquila itself does but it also would respond to commands for flight changes from the AVO, maintaining Aquila speed and other flight parameters (Bradford, 1985; USAFAS, 1985).

Apparently, there is some reluctance of the Army Aviation Branch to provide helicopters to support SATS since the RPV is viewed as usurping some of Aviation's surveillance mission. CW3 Bradford pointed out that Aquila would actually complement the helicopters during combat, not replace them. The RPV could identify and laser-designate targets which could be fired upon by helicopter-launched laser-guided missiles. The RPV could reduce the need for the helicopter to be exposed to direct enemy fire (Bradford, 1985).

6. Vehicle Identification Tapes/Disk

Exportable vehicle identification tapes or disks will be developed and used to maintain proficiency of GCS operators (USAFAS, 1985). These should be presented on the system CRTs or their equivalents in the institutional environment for optimal transfer of training.

UNIT TRAINING COSTS

Crashes of the million dollar Aquila RPV during training flights would probably dwarf fuel, personnel and maintenance costs associated with actual flights of the Aquila RPV for unit training. Substitution of the TIU and IAV for the actual air vehicle will undoubtedly produce great savings in training costs largely because fewer expensive air vehicles will be lost or damaged.

The projected training of operators through use of a sensor package strapped to a helicopter would also provide training more cheaply than flying actual air vehicles, again for the reason that damage and loss of expensive air vehicles does not occur (Bradford, 1985). Helicopter fuel, maintenance and replacement are not insignificant costs, however. These would make this "strap-on"-sensor training more expensive than TIU simulations. Additionally, the actual sensor package video (or FLIR) from actual air vehicle flights or helicopter flights would provide one unique advantage over the TIU CGI since the CGI does not fully simulate actual video. On the other hand, threat vehicles will not normally be visible from the strap-on device or actual air vehicle training like they are on the TIU.

SHIFT FROM TRAINING TO OPERATIONS MODE

Uncasing the TIU, moving it into the GCS van, plugging it in and bringing up a training scenario can be done in as little as five minutes. Similarly, the TIU can be unplugged and the system returned to operational use in less than five minutes. Given these rapid shifts to and from the training mode, training delays or interference with operational readiness will not be problems associated with use of the TIU (Smith, 1985).

TRAINING MANAGEMENT

Unit commanders have the responsibility to develop and implement a training plan that will enable the soldiers to learn and sustain individual and team skills. The plan must insure: that unit personnel are trained and ready for SQT evaluation; that the deficiencies attributed to formal training are reported to the appropriate schools so that corrective action can be initiated; and, that the SOJT program of the unit completes the individual training of soldiers. The plan must also provide for adequate retraining of soldiers for new MOS skills (USAFAS, 1984a). The O&O Plan (USAFAS, 1985) also schedules a great deal of unit training.

The RPV Battery Commander will insure that each section participates in combined exercises, command post and field training exercises as often as possible. Each section will be required to demonstrate proficiency to ARTEP standards annually. Additionally, each section should devote a significant amount of time to training in MOPP attire under simulated NBC battlefield conditions (USAFAS, 1985, p. 6-3).

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

Commanders will insure that personnel are trained and available for scheduled SQT test dates (USAFAS, 1984a). Observation of unit training following system fielding will be required to determine if soldiers and equipment actually are made available for training. One thing which may support large amounts of unit training is the fact that it is a new system and ingrained Army reluctance to train may be relatively less influential than for a system like HIP which only replaces an existing system.

ADEQUACY OF TRAINING SYSTEM

Operational readiness data obtained following system fielding will be needed to establish whether training is adequate. However, to the extent that ongoing OT II training proves to be successful and is emulated in future institutional and unit training, there is high potential for training to be adequate.

IMPEDIMENTS TO TRAINING

TIU scenarios may become overly familiar to operators following even moderate use. The Patriot experience, with reduced training value following initial scenario exposure (Bird, 1985; Sterback, 1985), suggests this may also happen with the TIU since the TIU has only five scenarios with fixed target arrays. This question should be investigated since many more TIU scenarios or more sophisticated scenarios may be needed to maintain operational readiness.

SUMMARY

The Aquila remotely piloted vehicle (RPV) is a small pilotless surveillance airplane equipped with a television camera (later a FLIR) plus a laser for designation of targets for precision guided munitions. The Aquila system also includes a truck-mounted launching rail, a truck-mounted catcher net, the tracking antenna, the computer that flies the RPV, the operators who control the RPV and its sensor package, and the GCS van that houses the operators and the computer equipment. An Aquila battery will consist of numerous air vehicles, three forward vans for flying missions and two rearward vans for launching and catching the aircraft. Much more extensive equipment and manpower than one might expect are required to operate this "model airplane". These factors and the high cost of the air vehicle and its sensor package make simulation more than cost effective for both institutional and unit training (Bradford, 1985).

The training simulator for unit training is known as the Training Interface Unit (TIU). This "strap-on" embedded trainer has already been fielded and although there are some bugs to be worked out, it is already proving its value even though Aquila is only at Operational Test II. The TIU uses computer-generated imagery (CGI) to simulate terrain and targets for operator displays. A multi-station institutional training simulator is still under development. It will use videodisc as a means to simulate the video from the RPV.

The critical role of the TIU in training military personnel for the Operational Test II provides a preview of how important embedded training will be for the fielded Aquila System. Only the Patriot System may provide a stronger Army system testimony than this Aquila System to the efficacy of embedded training. The failure of the TIU CGI to closely simulate the video provided by the Aquila sensor package also shows that fidelity of simulation may not be the best predictor or even an important predictor of the utility of an embedded trainer or other training device.

More operator feedback and more automatic inclusion of mission problems were planned for the TIU and these appear to remain important goals. Personnel with appropriate skills may not always be available to make training-relevant inputs to the TIU or to provide corrective or reinforcing feedback.

In addition to the need for much instructor input, other problems exist in the TIU. For example, the recovery vehicle did not show up on the scenario that we were viewing, although it is viewable on other scenarios. On the other hand, this system is still so new that the instructors may not yet be totally familiar with its operation. The low altitudes we requested in order to obtain closeup views of threat targets provided video displays that seemed to be as novel to the instructor operating the TIU and to his boss, CW3 Smith, as they were to us (Smith, 1985).

Newness of the TIU may have prevented the appearance of the problem of operator overfamiliarity with the limited set of training scenarios. Patriot's Troop Proficiency Trainer scenarios lose most of their training value with only four or five presentations. Research is needed to assess the probable need for

additional TIU scenarios to prevent loss of training potential through overexposure.

Apparently, there is some reluctance of Army Aviation to provide helicopters to carry the Surrogate Aquila Training System (SATS). This is a "strap-on" sensor package that would provide video/FLIR for operator/commander training identical to that provided by the air vehicle. CW3 Bradford (1985) pointed out that Aquila would actually complement the helicopters, not replace them. The RPV could identify and laser-designate targets which could be fired upon by helicopter-launched laser-guided missiles. The RPV would reduce the need for the helicopter to be exposed to direct enemy fire.

A VCR exists for recording video from the Aquila television camera (or from the TIU). It would appear that the video from Aquila missions and even from TIU or SATS missions should be routinely recorded since such videos would have much training value if viewed by Aquila GCS trainees. Audio dubbed onto these videos could enhance their training potential by pointing out significant targets. Probably the conversations of GCS personnel during video recording of the mission would serve this function. Only a 60-minute record time is currently possible and this system limitation should be corrected since missions are anticipated to be two to three hours in length and tape changing could interfere with operator performance.

A large part of Aquila operator training will be the responsibility of the Military Intelligence school. Currently, it is apparently planned that only 35-mm. slides will be presented of enemy targets as the means to increase target identification skills (Neil, 1985). For sustainment training, it would seem that these audiovisuals should be transferred to the GCS VCR for display on the operator/commander consoles. For institutional training it would appear that these tapes should be played on other VCRs and the video displayed on high-resolution 13" black-and-white monitors similar to those in the GCS.

If resources were available, it would be useful to replace the plotting board with a large color CRT and to provide color map graphics from a Harris Digital Map Generator. On these could be superimposed computer graphics corresponding to the programmed route of the RPV, a symbol indicating the present position and direction of the RPV, and a four-sided figure that accurately depicts the field of view of the sensor package seen on the monitor including a cross-hair at its range-finder/laser-designator "center." All terrain that is higher in altitude than the RPV and that interferes with line-of-sight communication with the RPV could be displayed in red to aid air vehicle navigation.

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APPENDIX G

ALL SOURCE ANALYSIS SYSTEM (ASAS/ENSCE)

CONTENTS

CONTENTS (continued)

APPENDIX G

ALL SOURCE ANALYSIS SYSTEM (ASAS/ENSCE)

WEAPON SYSTEM CHARACTERISTICS

1. Type of System

Tactical Military Intelligence Automatic Data Processing System

The All Source Analysis System/Enemy Situation Correlation Element (ASAS) is a joint Army and Air Force development, intended to serve the intelligence analysis needs of both services. It is a computer assisted, tactically deployable, modular all source intelligence processing system. It supports all major intelligence analysis functions based on data input from multiple field and remote sources. The Army version (ASAS) provides IEW (Intelligence/ Electronic Warfare) and OPSEC (Operational Security) to light and heavy units at division, corps and echelons above corps (EAC). The Air Force version (ENSCE) provides identical functions at similar levels. At each level, a common set of modules is employed to perform the entire suite of required ASAS functions. This review concentrates on the Army version.

ASAS is being developed on an accelerated basis, outside the formal Army Material Command (AMC) acquisition process (the Life Cycle Systems Management Model, or LCSMM). This accelerated development is under the aegis of a Joint Oversight Group (JOG) co-chaired by the Vice Chiefs of Staff of the Army and Air Force. The JOG oversees the Joint Tactical Fusion Office (JTFO) which serves as the "Program Manager", or PM, for the system. This extraordinary acquisition process, which has bypassed some formal steps in the procurement cycle, was instituted to meet the urgent joint needs of the Army and Air Force for intelligence processing as quickly as possible.

2. System Components

ASAS consists of several component elements, deployed at four tactical levels - brigade, division, corps, and echelons above corps (EAC). When interconnected in a data/voice communication configuration, these components operate in a system mode. Some components have a standalone capability to perform their assigned mission. Also, for some components only general descriptions and characteristics are available due to the early stage of system development.

ASAS is scheduled for acquisition in two phases: the "baseline" phase and the "objective" phase. The baseline phase also has two baseline system procurement steps and each step has two procurement substeps. Due to the extraordinary development process, it must be kept in mind that the ASAS system components described here are those of the final, or "objective", system (Ammon, 1985a; United States Army Intelligence Center and School [USAICS], 1983, 1984, 1985a).

a. General

The ASAS will be designed for continuous operations (degraded during relocations) in an all-weather combat environment with application to crises, contingency planning, exercises and peacetime support requirements. ASAS elements will generally be deployed within 5 kilometers of the division/corps TOC and 1-3 kilometers from the brigade TOC. Modules will be ruggedized and configured in standard environmentally controlled, tactical shelters. Shelters will contain dismountable workstations, ADP hardware/software, inter/intra shelter communications and connections for external communications and power (USAICS, 1983, 1984, 1985a).

The ASAS interface/workstation is the key to the ASAS ADP capability at all levels. The interface allows individual analysts and operators to input to and/or examine the intelligence database(s) developed in ASAS. Due to recent decisions (Ammon, 1985b), the standard ASAS interface will include a full 32-bit microcomputer, which will provide a standalone capability for local data processing based on locally available and locally input data. Each interface/ workstation will contain dual-screen alphanumeric and color graphics display capabilities and full data entry and retrieval capabilities. A hardcopy printer, a modem and communications security (COMSEC) equipment are also included (Ammon, 1985b).

This basic interface will be the workstation component for all data processing modules of the ASAS system: the forward sensor interface and control (FSIC) module, the ASAS interface module (AIM), the intelligence data processing (IDP) module and the communication processor and interface (CPI) module. The RAD, or radio module, will not include the ASAS interface. Thus, the interface capability for retrieval and processing of limited data will be available at all echelons of ASAS. The interface will be incorporated (as the PAWS - for portable ASAS work station) into a remoted workstation (RWS) to provide the individual unit's interface to ASAS. It can be remoted, via cable from the AIM, to serve various locations as required, (e.g. - brigade, division or corps TOCs and CPs) (Ammon, 1985a, 1985b; USAICS, 1985a).

The anticipated utilization of ASAS interfaces/workstations by unit type and function is illustrated in Table G-1. The table also indicates the current planning for distribution of the ASAS workstations within each unit type. Other than those interfaces indicated as RWS (remoted), the workstations will be housed within the various modules of ASAS described below.

b. The ASAS Modules

The forward sensor interface and control (FSIC) module is a shelter housed, vehicle mounted, mobile, ASAS subsystem to be assigned in the brigade area. As an asset of the Military Intelligence (MI) battalion, the FSIC receives information from multiple sources and transmits it to the division ASAS. The system recognizes and transmits high priority information to the brigade tactical operations center (TOC) and/or brigade command post (CP) via the TA team. The FSIC will provide the brigade commander, through the S2 and

Table G-1

ASAS Interface/Workstation Distribution and Utilization By Unit Type and Function

Module Workstations	Light Div MI TOC	Light Div Spt Elm	Heavy Div MI TOC	Heavy Div Spt Elm	Light Corps MI TOC	Light Corps Spt Elm	Heavy Corps MI TOC	Heavy Corps Spt Elm
Functions:	6	6	9	9	12	12	12	12
Asset Mgmt								
COMINT								
ELINT	L	-	M	-	H	-	H	-
CEI (SIGINT)	H	-	H	-	H	-	H	-
MTI/FTI	L	-	L	-	M	-	M	-
HUMINT	L	-	M	-	M	-	M	-
RM/MM Mgmt	L	-	L	-	M	-	M	-
ASP	L	-	L	-	L	-	L	-
SITDEV	-	M	-	M	-	M	-	M
TGTDEV	-	M	-	M	-	H	-	H
OPSEC Spt	-	M	-	H	-	H	-	H
	-	M	-	M	-	M	-	M
Remote Workstations	-	L	-	M	-	M	-	H
G2 (INTEL)								
G3 (EW/FSE)								
G3 (OPSEC)	-	L	-	H	-	H	-	H
	-	L	-	L	-	L	-	L
Other RWS	-	L	-	L	-	L	-	L
Locations:	TAC CP ACAB BDE TOC (3) FA OPS		TAC CP DIV CAV SQDN BDE TOC (3) FA OPS		TAC CP FA OPS ACR SEP BDE AEB		TAC CP FA OPS ACR SEP BDE AEB	

Legend: Proportionate Use:
- H = High (2-4 workstations)
- M = Medium (1-2 workstations)
- L = Low (1/4 - 1 workstations)
- \- = Function not Performed

(USAICS, 1985a)

S3 officers, with current, high priority, battlefield intelligence information. The FISC also relays information to the ASAS intelligence data processing (IDP) module at division headquarters and provides a downlink for sensor/EW management. Five FISCs per division are being procured (Ammon, 1985a, 1985b).

The FSIC contains the standard interface/workstation described above and also provides two means of communication: data and voice. Both methods are provided with communications security equipment. Data links are provided to division for interface with other ASAS components and to the assigned sensor systems. Similarly, voice communication is provided to division and brigade headquarters elements and to non-automated sensor system operators. The FSIC interface includes the microcomputer and the multiple graphics and display capabilities mentioned above. It also includes a line printer. A 10,000 watt (10 KW) electrical power generation capability is provided.

Intelligence and electronic warfare (IEW) information comes from a variety of sources. The FSIC is capable of providing filtered, near real time, tactical information gathering, processing, analysis and reporting to its attached brigade. It also passes this information to the division ASAS information data processor (IDP). Potential FSIC information sources organic or attached at the brigade level are shown in Table G-2 (Ammon, 1985a; USAICS, 1983, 1984, 1985a, 1985b). Some information will be provided to the FSIC through sensor system data links, while other information will be supplied via voice and messenger and entered manually. Sensor data link interface hardware/software has not been completely developed (Ammon, 1985a; National Aeronautics and Space Administration, Jet Propulsion Laboratory, California Institute of Technology [NASA, JPL], 1985a).

<u>The ASAS interface module (AIM)</u> is a shelter housed (S-250), truck-mounted, mobile ASAS subsystem with ASAS interface or standalone capability. The AIM provides the necessary interface for the remote workstations (RWS) within the division TOC, division CP and the various working sections of the MI battalion. The AIM also provides commanders of task force and separate tactical commands with full MI capability. Procurement of five (5) AIMs per division and three (3) per corps is planned (Ammon, 1985a). The AIM can interconnect up to six (6) microcomputer workstations or 1-3 ASAS remote workstations (RWS) which can be operated at the TOC, CP, and Armored Cavalry, Aviation and other battalion TOCs (Cf. Table G-1).

The AIM provides the full range of intelligence processing and database transmission capability inherent in the design of the standard interface and the local data availability. It has communications capability similar to that of the FSIC, and is equipped with a 10,000 watt (10KW) electrical power generation capability. Depending upon terrain, distance and enemy electronic countermeasure (ECM) factors, the AIM may require a dedicated radio relay link/hard wire/SAC to the division ASAS (Ammon, 1985a; USAICS, 1983, 1984, 1985a).

<u>The communication processor and interface (CPI) module</u> is a shelter mounted (S-280), 5-ton-truck-mounted, mobile, ASAS subsystem that provides access to external communications and intra-enclave communications for data/voice networks, and performs communications security functions. The CPI

Table G-2

FSIC Interface Capabilities

Information Source	Company	Battalion	Brigade	Attached
Troops	X	X	X	X
Patrols	X	X	X	X
POW Interrogation	X	X	X	X
Counterintelligence		X	X	X
FIST	X	X		
Ground Surveillance Radar	X	X		X
REMBASS		X	X	
*Ground & Aerial Interception, Direction Finding & Jamming Systems			X	X
TACFIRE/AFATDS		X		X
Firefinder		X	X	
RPV				X
ADA Target Acquisition Radar				X
Aerial Photography				X
Terrain Conditions	X	X	X	X
Weather Conditions				X

Note. *These radio and radar sources include: AN/TRQ-32 TEAMMATE, AN/TSQ-114(MC) TRAILBLAZER, AN/TLQ-17A TRAFFICJAM, AN/MLQ-34 TACJAM, and AN/MSQ-103 TEAMPACK

serves as the communications controller for all ASAS components. It is capable of prioritizing, queueing, monitoring, and selectable switching of all externaland internal communication of ASAS components. It has built-in equipment and functions that provide internal and external security for the system. Procurement of two (2) CPIs per division and two (2) per corps is programmed (Ammon, 1985a; USAICS, 1983, 1984, 1985a).

In addition to the standard interface microcomputer capability, the CPI has a communications message processor (Norden VAX 11/750R), a main memory capability with disk storage, a security release computer (Norden PDP 11/84) with two (2) CRT terminals, disk storage, a line printer, magnetic tape unit and other peripherals.

It has a 12-channel communications protocol processor for external data communications, an interface to the inter-enclave communications link, and voice communication and interface equipment. The CPI is equipped with 30,000 watt (30 KW) power generating equipment.

The intelligence data processing (IDP) module is a shelter housed (S-280), 5-ton-truck-mounted, mobile ASAS subsystem which receives, processes, stores and transmits information to support analysis, production and dissemination of military intelligence at the division TOC and MI battalion. The IDP is where the divisional main database is developed and housed. Data forwarded from the brigade FSICs and separate AIMs are combined, screened, correlated, processed and stored here. Analysts in the division TOC, CP, and the Combat Electronic Warfare and Intelligence (CEWI) section of the MI battalion interact with this database to perform their analyses and develop reports. Separate area analysts can extract their specific functional area information, analyze the raw reports, rank order possibilities, produce graphic depictions, generate intelligence predictions and compile reports concerning their specific functional area. The IDP has three (3) workstations, two (2) computers, disk storage capability, a line printer and a magnetic tape unit. It can interface to the local area network (LAN) and has a 30 KW electrical generator (Ammon, 1985a; USAICS, 1983, 1984, 1985a). Procurement of four (4) IDPs per division and six (6) per corps is planned (Ammon, 1985a; USAICS, 1983, 1985a).

A radio module (RAD) is also included in the ASAS system. The AN/TRC-113 is used to electronically collocate the CEWI Ops and TOC Support Element enclaves at both division and corps.

c. System Configuration

The objective division ASAS is planned to work in the following manner. Input sources (sensors, jammers, moving target radars, human intelligence sources and other members of the MI battalion supporting a brigade) provide information which is processed through the FSIC. Information critical to brigade operations is reported to the brigade S2 and S3. All information is transmitted, over data/voice links, to the division CPI. Here, it is further transmitted to the specified recipient. Normally, all data transmissions will go to the IDP where the information is digitally and manually processed. Remote workstations interfaced through the AIM can access this database to perform their functional area assignments. This IDP is also interfaced, via the CPI, with higher and parallel headquarters for two way communications Ammon, 1985a; NASA, JPL, 1985a; USAICS, 1983, 1984, 1985a, 1985c). Table G-3 shows the planned ASAS interface capabilities at division and corps level (Ammon, 1985a; USAICS, 1983, 1984, 1985a).

The objective corps and echelons above corps (EAC) ASAS will operate in a similar fashion except they will utilize different information sources and will not require the forward area FSIC or the RAD (radio module). Also the numbers of the other modules (AIM, CPI and IDP) will vary according to echelon (Ammon, 1985b; NASA, JPL, 1985a; USAICS, 1985a).

MISSION

ASAS supports the division and corps commander by the automated data processing (ADP) of large volumes of combat information and intelligence from all sources to provide timely IEW and OPSEC support, to include targeting

Table G-3

Division/Corps Interface Capabilities

Division Sources	Corps Sources
Quickfix	Quicklook
SLAR (via Corps)	SLAR
Guardrail V (via Corps)	Guardrail V
Quicklook (via Corps)	National Hookup
Adjacent Division ASAS	Echelons above Corps ASAS
Theater Hookup	Other services
Command, Control & Subordinate Systems (CCS2)	Command, Control & Subordinate Systems (CCS2)
FSIC	Adjacent Corps ASAS
RWS in Division area	Division ASAS
	RWS in Corps area

information and threat assessment. The ASAS incorporates ADP-assisted capabilities to accept, evaluate, correlate, file, display, process, analyze and report intelligence from all sources. The result is a fused all source intelligence picture of the battlefield. The system incorporates features required to assist in producing intelligence to support battle management needs in a dynamic environment, to include the effective and efficient management of the collection effort in response to the commander's requirements. The baseline ASAS will provide an early capability to be improved through evolution and product improvements to the fully-functional highly automated objective ASAS in the 1990s. All software for the system will be written in the Ada programming language (USAICS, 1983, 1984, 1985a).

The ASAS will interface across three distinct architectures: the national/joint/allied intelligence architecture; the Command, Control and Subordinate Systems (CCS2) architecture; and, the organic intelligence and

electronic warfare (IEW) architecture (USAICS, 1983, 1984, 1985a). Each ASAS will operate within the established intelligence network (G2, G3, TOC Support Element, MI battalion operations center, subordinate companies and other joint/allied combined intelligence centers) for the exchange of combat information and intelligence. This activity will provide commanders and their staffs with common perceptions of the battlefield, the identification/location of potential targets and a dynamic current assessment of threat capabilities and intentions (USAICS, 1983, 1984, 1985a).

The ASAS is organic to HHC, MI battalion (CEWI), at division; to the Operations Company, Operations Battalion, MI Group (CEWI), at corps; and the Intelligence Center, Intelligence Battalion, Intelligence Group (EAC), at EAC. ASAS will be manned by organic MI personnel who may be attached to brigade and

separate task force units with their ASAS components (USAICS, 1983, 1984, 1985a).

The operational mission of ASAS includes nine functional areas, as defined by the Operational and Organizational Plan. These are:

System Supervision

Collection Management
  Requirements Management
  Mission Management
  Asset Management

Intelligence Message Processing

Single Source Analysis
  COMINT
  ELINT
  CEI

All Source Processing (ASP - including preprocessing)
  Moving Target Indications (MTI)
  Fixed Target Indications (FTI)
  HUMINT

Situation Development

Target Development

Electronic Warfare Support

Operational Security Support

The general configuration of the computer operating system and database files is designed to support all of these nine functional areas with special emphasis on the major product areas described below (Ammon, 1985a; USAICS, 1984, 1985a).

1. Collection Management

A subsystem of ASAS is dedicated to requirements management, mission management, and asset management (NASA,JPL, 1985b). These functions are performed partly in the support element (requirements and mission management) and partly in the MI TOC (asset management). Requirements management is the process of logging new collection requirements, insuring that the information is not currently available, translating the intelligence requirement into a specific request for specified information collection and evaluating the status of the collection process (NASA, JPL, 1985b).

Mission management is responsible for determining if collection requirements are supportable with either organic or nonorganic resources. This

is essentially a planning function with the end result being a tasking message or request (NASA, JPL, 1985b).

Asset management is done in the TOC by intelligence requirement area: there is a manager for each of imagery intelligence (IMINT), signals intelligence (SIGINT), human intelligence (HUMINT) and communications intelligence (COMINT). There is also an overall asset manager who supervises the entire operation. A list of possible assets to meet the collection needs is developed by the individual intelligence area manager. The asset manager then selects the specific assets to be used in developing the mission employment plan. Specific assets are tasked to carry out the collection via tasking messages. The area manager also monitors the current operations to insure that mission employment plans are completed successfully (NASA, JPL, 1985b).

2. Intelligence Message Processing and Analysis

The interface 32-bit computer in each ASAS module will allow maintenance of local databases identical to, but smaller than, those in the IDP at division level. Database entries will be by keyboard in 20 specific item entry message formats. These messages will be transmitted, via data link, through the ASAS communication processor and interface (CPI) module to the ASAS intelligence data processor (IDP) (Ammon, 1985a; USAICS, 1983, 1984, 1985a).

Information from these messages is then processed and integrated with data sent by other elements to form an integrated divisional database of specific functional area conditions. These element-specific databases and new intelligence messages are processed by the individual intelligence area analysts (ELINT, COMINT, etc.) to produce the individual area databases as component parts of the ASAS database. The specialists then draw on these databases to perform their asset management and related analyst duties. The single source analysts use the full automated capabilities to produce their single source reports and other products. CEI and All Source analysts also have complete support for their analytic requirements, with full access to and capability for manipulation of elements in the database. Intelligence processing, forwarding and database storage and retrieval are fully supported by automated procedures within the ASAS design configuration. Eight (8) additional message formats are used at this level. The division ASAS will also transmit formatted messages to the corps ASAS where the same functions are performed. The corps ASAS will also transmit to the EAC ASAS (Ammon, 1985a; USAICS, 1983, 1984, 1985a).

3. Situation Development

This process analyzes current battlefield conditions and predicts enemy courses of action. Primary inputs are from files created by all source analysis. All source processing (ASP) and analysis consists of validation, of messages, creation of functional element databases, creation of moving target indicator (MTI) records, processing of textual messages and battle damage reports and maintenance and manipulation of the all source database. ASP is supported by statistical packages, for evaluation of human intelligence and

moving target trend analysis, and by a report and message generation capability (Fletcher, Gaimori, Kendrick, Miller and Rudsill, 1985).

Situation maps are the primary products of the situation analysis function. They are interpreted, filtered and simplified depictions of the order of battle and other all source databases. The maps and overlays can be produced in hard copy form (Elliott & Friedman, 1985); however, a specific intent of ASAS is to automate the presentation, as well as the development, of situation maps and overlays. It is intended that the graphic displays and outputs provided will replace, or greatly reduce the requirements for, the labor intensive, hard to handle, hard copy materials (Ammon, 1985b).

4. Target Development

This process identifies and develops targets for attack. Functionally, the process examines potential targets to determine military importance and weapons required to obtain a desired level of damage or casualties. It follows a five level process: criteria development; immediate target processing; target development; target nomination; and, combat assessment (Jaivin, Garcia, Groff, Kramer, Leavitt & Yao, 1984).

5. Electronic Warfare (EW)

This ASAS/ENSCE subsystem plans, tasks and evaluates Electronic Countermeasure (ECM) operations. Specific subfunctions of EW support are electronic warfare support measures (ESM), electronic counter counter measures (ECCM) and electronic countermeasures (ECM). The major outputs of ECM are the development of preplanned deployment of assets, the generation of tasking messages or recommendations to the jammers, requests for additional ECM technical data and the evaluation of jammer operations. There are four major task areas in this functional area: initial ECM mission planning; dynamic ECM mission planning; ECM performance evaluation; and, ECM database maintenance (Dolinar, Hughes, & Clark, 1985).

6. Operational Security (OPSEC)

This is the ASAS/ENSCE subsystem which identifies the friendly force profile and friendly force vulnerabilities. Within this framework, there are three major tasks, eight (8) major subtasks, 28 sub-subtasks and 59 minor level tasks (NASA, JPL, 1985c).

HISTORY OF SYSTEM ACQUISITION

A requirement for automating the analysis of military intelligence functions was recognized and partially met with such systems as the Tactical Control and Analysis Center (TCAC), the Joint Tactical Fusion Test Bed (JTFTB) (formerly the Battlefield Exploitation and Target Acquisition [BETA] system) and the Intelligence Information Subsystem (IISS). These systems, however, did not meet the requirement of producing filtered, analyzed, military intelligence information to the battlefield commander in a near real time manner. Automated intelligence gathering systems, collectively, produce intelligence data at a

prodigious rate. However, the present capability to process, correlate and analyze data to produce a usable intelligence product for the battlefield commander remains at the World War II level of capability - a soldier, a pencil and a piece of paper (Ammon, 1985a; USAICS, 1985c).

A decision was made sometime in late 1979, early 1980, to proceed with system acquisition under an accelerated and evolutionary development program. This included development of the ASAS under direction of the Joint Tactical Fusion and Integration Office rather than through AMC. System development is being expedited to provide an initial operational capability to the field at the earliest possible date. To achieve this goal, maximum use of off the shelf equipment and existing technology is necessary. Reflecting this expedited approach, HQDA authorized the program to proceed past Milestone II based largely upon success and experience with predecessor systems. This concept was delineated in the Mission Essential Needs Statement (MENS) that HQDA submitted to OSD on 30 June 1981. With approval of this concept, the program passed Milestone II without an approved ROC or system developmental testing. Consequently, there is a need for continuous review and update of plans and programs throughout the system acquisition cycle (Ammon, 1985a; USAICS, 1985c).

Embedded training was specifically addressed in the MENS, the ROC, the O&O Plan, Outline ICTP and ICTP. Training was also a deficiency noted in the 1983 Electronic Warfare Mission Area Analysis (Ammon, 1985a; USAICS, 1983, 1984, 1985a, 1985c). Embedded training is also defined as a deliverable with the objective system (Alston, 1985; Ammon, 1985a; USAICS, 1985c). It is apparent that from concept initiation some form of embedded training was foreseen as required in unit sustainment training.

ASAS is being developed under a joint program with the US Air Force. The Air Force counterpart to ASAS is the Enemy Situation Correlation Element (ENSCE). Two acquisition phases have been identified for the ASAS:

1. Procurement: Baseline Phase

During this phase the initial system components and software will be developed and upgraded until enough success has been achieved that the production of the final objective system can be assured. It is also referred to as the limited capability configuration (LCC) phase. This phase has two subphases of equipment procurement. The first will procure RDTE Equipment (militarized) for delivery to Fort Hood for developmental and operational testing. This testing will be conducted in two phases which are expected to run through 1990. Equipment will be utilized by the assigned units to support contingency and operational missions. This equipment includes: two (2) each FSIC and AIM, to be delivered in September 1985; and, two (2) each CPI and IDP, to be delivered in the fall of 1987 (Ammon, 1985a; USAICS, 1984, 1985a).

The second subphase is for limited procurement (LP) of product improved versions of AIM, FSIC, CPI, IDP and radio components based on results of Development Test/Operational Test II on the RDTE components. The LP phase components will also undergo developmental and operational testing to define a full scale production model. Software deliverables are also scheduled. Equipment issued during this phase will also be utilized for contingency and

operational missions. This will include: six (6) AIMs and seven (7) FSICs in fall of 1988; and, two (2) CPIs and four (4) IDPs in the fall of 1989 (Ammon, 1985a; USAICS, 1984, 1985a, 1985c).

This acquisition schedule for RDTE and LP equipment is compared with the planned objective system acquisitions in Table G-4.

Table G-4

ASAS Procurement Projections.

	Baseline		Objective			
			Division		Corps & EAC	
Module	RDTE	LP	Req	Proc	Req	Proc
IDP	2	4	8	4	13	6
CPI	2	2	4	2	4	2
AIM	2	6	9	5	6	3
FSIC	2	7	5	4	0	0

(Ammon, 1985a)

2. Procurement: Objective Phase

This phase includes full scale production of the ASAS which will be issued to division CEWI battalions beginning in 1990. This will be a product improved version of ASAS components evaluated during the baseline, limited production phase. A continuous P^3I program is anticipated for this system. Air Force components comprising the ENSCE will be delivered during this phase (Ammon, 1985a; USAICS, 1984, 1985a).

PERSONNEL AND KEY JOB TASKS

The requirements for commissioned officer, warrant officer and enlisted MOSs for the ASAS system to provide management, operations and maintenance are indicated in Table G-5. Commissioned and warrant officers will perform mainly management and operator/analyst duties, while enlisted personnel will be primarily operator/analysts and maintenance personnel (DA, 1985a; USAICS, 1983, 1985c).

ASAS management includes such functional duty positions as system *supervisor, asset manager and requirements/mission manager. Duties include* such functions as analysis of the situation, selection of assets, asset tasking, mission management and product evaluation (USAICS, 1985c).

Table G-5

MOS and Duty Title of Personnel Expected for ASAS.

Commissioned Officers

MOS	Title
35A	Tactical Intelligence
35B	Strategic Intelligence
35C	Imagery Exploitation
35E	Counter Intelligence/Human Intelligence Unspecified
35F	Human Intelligence
35G	Tactical/Strategic Signal Intelligence/Electronic Warfare

Warrant Officers

MOS	Title
962A	Image Interpretation Technician
964A	Order of Battle Technician
982A	Traffic Analysis Technician
983A	Emanations Analysis Technician
988A	Voice Intercept Technician

Enlisted Personnel - Military Intelligence

MOS	Title
96B	Intelligence Analyst
96D	Image Interpreter
98C	Electronic Warfare/Signal Intelligence Analyst
98G	Electronic Warfare/Signal Intelligence Voice Interceptor
98J	Electronic Warfare/Signal Intelligence Non-Communication Interceptor

Enlisted Personnel - Maintenance

MOS	Title
33T	Electronic Warfare/Intercept Tactical Systems Repairer

(USAICS, 1985c)

ASAS operator/analyst functional duty positions include All Source Analyst, Target Analyst, Operations Security Analyst, HUMINT Analyst, COMINT Analyst, ELINT Analyst, and COMINT-ELINT Integration Analyst, Situation Analyst, and Fixed and Moving Target Indicators Analyst. These positions will include such functions as analyzing specific functional area information, seeing correlation, drawing conclusions, making extrapolation, drawing from existing databases, manipulating the information through alphanumeric and graphics capability, creating new databases, sending information, responding to requests for information, requesting asset tasking and evaluating new information. Operators are also responsible for preventive maintenance of all assigned equipment (Alston, 1985; Ammon, 1985a; Dolinar, Hughes & Clark, 1985; Elliott & Friedman, 1985; Fletcher, et al, 1985; Jaivin, et al, 1984; NASA, JPL, 1985b, 1985c) .

ASAS maintainers are responsible for organizational and intermediate maintenance of ASAS components, including communication equipment, ADP, special devices, communication security devices, vehicles, environmental control equipment and power generating equipment (DA, 1985; USAICS, 1985c).

ASAS officers, warrant officers and enlisted personnel will interact directly with the system in the functional areas indicated in Table G-6.

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

1. Displays

The Required Operational Capabilities (ROC), dated 15 September 1983, indicates the following ASAS display requirements for dismountable remote workstations (RWS). An alphanumeric screen must be provided with visual clarity sufficient to allow the operator to read 80 characters per line with 24 lines visible per screen page (USAICS, 1983). A color graphics display is required to provide high resolution display with the screen being approximately 19 inches in diagonal size. The graphics display must be capable of displaying digitized terrain data, terrain products and digitized weather data and products. It must be capable of saving individual symbols, groups of symbols or all symbols on a screen; varying the scale of all displayed information; and, decluttering a screen (USAICS, 1983). A hard copy printer for alphanumerics and graphics must also be provided (USAICS, 1983).

Each ASAS must also include at least three (3) large (1 meter X 1 meter) graphic displays as developed by the SIGMA program. These displays must be capable of being driven by any ASAS portable or remote workstation (USAICS, 1983).

2. Indicators

Very little in the way of hardware descriptions for the ASAS is available at this time. However, since the system is principally electronic communications and automatic data processing equipment, it can be assumed that the indicators will be those usually associated with this type of equipment. This usually consists of elements such as LED lights, buzzers, meters,

Table G-6

ASAS Operational Specialties Distribution

	Military Occupational Specialty												
	Officers			Warrant Officers					Enlisted				
Functional Area	35 A/B/C	35 E/F	35 G	962A	964A	982A	983A	988A	96B	96D	98C	98G	98J
System Supervision	X		X	X	X	X	X	X					
Asset Management	X		X	X	X	X	X	X			X		X
Moving Target Indicators	X			X					X	X			
Fixed Target Indicators	X			X					X	X			
HUMINT (Human Intelligence)		X											
COMINT (Communication Intelligence)			X			X		X			X	X	
ELINT (Electronic Intelligence)			X				X						X
COMINT-ELINT Integration			X			X	X				X		X
Requirements/Mission Management	X		X	X	X	X	X	X					
All Source Processing	X		X	X	X				X		X		X
Situation Development	X		X	X	X				X				
Target Development	X		X	X	X				X				
Electronic Warfare Support	X		X			X	X	X			X	X	
Operations Security Support	X	X		X	X	X	X		X	X			

(USAICS, 1984)

alphanumeric LED or liquid crystal readouts, etc.. It is assumed that some indicator information will be presented on the operator CRT as well.

3. Controls

Specific information about system controls is not available. However, considering the system components, it can be assumed that certain controls will be available (e.g. - a data entry keyboard and "mouse" or joystick for computer interface; dials, switches, pushbuttons, knobs, etc. for operation of electronic and communications equipment).

COMPUTER CAPABILITIES

The ASAS components will possess the computer capabilities listed in Table G-7 (Ammon, 1985a).

Table G-7

ASAS Component Computer Capabilities

Component	Computer Capabilities
Interface/ PAWS/RWS	32 bit computer with magnetic storage varying based on location and module (9 MB to 320 MB storage), and a magnetic tape unit for off-line storage
CPI	Norden VAX 11/750R Communications Message Processor computer with 8 megabytes main memory, 800 megabyte disk storage capacity
	Norden PDP 11/84 Security Release computer, 320 megabyte disk storage and magnetic tape unit for off-line storage
IDP	Dual 32 bit computers, 1120 megabyte disk storage with magnetic tape unit for off-line storage

The size of on-line storage must be controllable by the system supervisor up to a minimum of 3 days of average wartime volume. Off-line storage must be manually controlled, but sized for a maximum of 30 days (USAICS, 1983). The system must be capable of building and maintaining directories during creation, storage, retrieval and purge of data. These directories should include, as a minimum, file names, date of activity, size of files, type file and type storage (USAICS, 1983). Automatic and manual purges of on-line storage will be provided. Adjustable thresholds and resultant warnings to the system operator/supervisor are necessary (USAICS, 1983). Record traffic prepared in

the ASAS will be capable of direct transmission through the organic communications facility into the area communications system without manual intervention (USAICS, 1983).

The ASAS will be capable of automated processing, filing and displaying of JINTACCS and appropriate NSA USSID formatted record traffic input to the modules through the organic communications facility. This includes maintaining a record copy of all incoming/outgoing messages and on/off-line storage. Excerpts of the messages will be maintained on-line in appropriate files. These on-line entries will include a roll-up line, indicating last time the intelligence was seen, first time seen, location, sources reporting on the item and number of times reported. The on-line entries will also include the capacity to store extracts of up to ten key reports supporting the roll-up (USAICS, 1983).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

ASAS will operate in an on-line mode in battle and also in peacetime training. Inputs in the two modes will be nearly identical (when training under SCI restrictions, they can be identical) and both real and simulated inputs could be combined in a training situation. Thus, the equipment processing support will simulate combat tasks exactly, provided that the higher density of inputs anticipated in battle can be simulated in training. Computer memory, man machine interface and component communications are more than adequate to provide sustainment training for the management or operator/analyst personnel. It can also provide the testing required to assure both individual proficiency and unit readiness. Each ASAS module has sufficient resources and capabilities to support separate part task training for the individual interfacing with the module, and, when interconnected as a system, the ASAS has fully adequate simulation capability to support whole task training.

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

Feedback from the system equipment is likely to be in the form of system response to specific inputs by the operator/analyst or other user. Changes in displays, messages or data arrays will result from input by the user and will tend to indicate correct or incorrect inputs. If embedded training is developed with the system (and to some degree in any case), one could expect some menu or format indicators of correct response to computer inputs. There are no current specific plans for formal measurement or feedback of performance by any users or maintainers of the system. System feedback can be quite simply accomplished through the CRT or printer on a continuous or intermittent schedule. Feedback in the operational mode occurs mainly through CRT messages when the operator has exceeded some predefined parameter.

System feedback to the maintainer is only accomplished through reading of various system indicators upon some interaction with the system. No embedded training capability is planned for system maintainers.

The system managers perform their monitoring capabilities and responsibilities through evaluation of products/reports submitted by information producers within their domain. Performance is evaluated on a subjective basis during the operational mode and feedback provided via message and/or voice traffic. Accuracy of feedback for team training operations will depend upon the structure and parameters of the embedded training program.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

There is no planned institutional training for the baseline ASAS. Unit training for the baseline ASAS will initially be provided by a factory trained New Equipment Training Team (NETT), utilizing contractor developed training materials. All subsequent training will be conducted within the unit.

Institutional training for the objective ASAS will be provided through integration of the ASAS into already existing operator programs of instruction (POI). An initial four week ASAS operators course is scheduled for individuals who receive their primary intelligence courses at locations other than Fort Huachuca (e.g. - Devens graduates, Air Force and reserve personnel). A manager's course and a maintainer's course are also scheduled for presentation. Training devices will be programmed into the institutional phase of ASAS training. Unit sustainment training for ASAS operators is to be conducted with embedded training.

EXISTING/PROPOSED INSTITUTIONAL TRAINING

No resident institutional training is anticipated during the ASAS baseline systems phase (Alston, 1985; USAICS, 1985c).

1. Objective Phase Training

The objective phase training philosophy is that the system is a new tool to support existing task requirements, and these tasks are already being trained in existing resident courses. The conversion, from training these tasks to be performed with paper and pencil (in most cases) to training using ASAS' automated support (ADP files management), is believed to be relatively simple: it requires only training on what these automated support capabilities are and how and when they must be used. Therefore, it is thought to be most cost effective to integrate ASAS task training into the existing course structure. Modifications to existing individual training plans (ITP) are to be completed in 4Q FY88 (Alston, 1985; USAICS, 1985c).

Subsequent ASAS/ENSCE training courses will be taught on a continuing basis to personnel from the US Air Force, reserve components and the Fort Devens, MA, Intelligence School. With the exception of the maintainer course, these courses are eventually to be integrated into normal resident training programs (Alston, 1985; USAICS, 1985c).

A four (4) week ASAS/ENSCE Operators course will train skill level 1 through 4 personnel on system capabilities, workstation functions, operational interfaces and message formats. The final week will consist of a 126 hour command post exercise (CPX) in an operational system, in concert with participating manager and maintainer courses (Alston, 1985; USAICS, 1985c). A two (2) week ASAS/ENSCE manager's course will be designed for officers, warrant officers and selected senior NCOs who will manage the system at all echelons. Two days of the second week are dedicated to CPX involvement (Alston, 1985; USAICS, 1985c).

A four week ASAS/ENSCE Maintenance course is designed to train MOS 33T personnel on system peculiar equipment, configuration and operations. This will be a follow-on course for those individuals selected from the 33T10 course, taught at Fort Devens, to maintain ASAS and they will be monitored on a by-name basis, world-wide. The first week is taken in conjunction with the operators course, while the last week is dedicated to equipment maintenance during the CPX (Alston, 1985; USAICS, 1985c).

2. Institutional Training Devices

The requirement for a new training facility to house system training devices has been identified. The All Source Analysis Training Center (ASATC), project number T200, has an estimated cost of $9.651 million and a scheduled completion date of FY 1989. It will consist of 22 classrooms, 5 maintenance laboratories, computer and vault area, 7 equipment mock-up modules and other supporting operational areas. The facility will accommodate approximately 2,145-3,835 students per year and 80 instructor/support/administrative personnel. It will also have an adjacent hardstand with facilities for on-site training (CPX), such as permanently emplaced communications cables and commercial power drops with power converters (Alston, 1985; USAICS, 1985c).

a. Low Level Simulator

A requirement for 165 low level simulators has been identified in a Commercial Training Device Requirements letter deliverable in 3rd quarter of fiscal year 1988. These simulators will consist of a microcomputer, disk drives and monitor. It is hoped that the embedded training developed for sustainment training can be implemented on these simulators. The low level simulators will be used for initial instruction (Alston, 1985; Ammon, 1985a; USAICS, 1985c). Items to be taught are:

(1) Interface usage;

(2) System graphics capabilities;

(3) Communications select panel operations;

(4) ASAS Workstation familiarization;

(5) Database Files/Queues Practical Exercises; and,

(6) Message preparation/reporting practical exercises

b. Equipment Simulator/Mock-Up

Reference to equipment simulators is made in several documents; however, specific information about these simulators is not available at this time. They are scheduled to aid in the instruction of low level simulator objectives, external system cabling and internal system cable patching (Alston, 1985; Ammon, 1985a; USAICS, 1985c).

c. Operational All Source Analysis System

An operational ASAS will be located on the facility hardstand. It will be interfaced with a Tactical Simulation (TACSIM) system which will provide six (6) ASAS scenarios, each 4 days in length, for the end of course CPX (Alston, 1985; Ammon, 1985a; USAICS, 1985c).

EXISTING/PROPOSED UNIT TRAINING

The ASAS Mission Element Needs Statement (MENS), Required Operational Capability (ROC), Operational and Organizational (O&O) Plan, and Individual and Collective Training Plan (ICTP) refer to a requirement for embedded training to support unit sustainment training. They do not state for which phase embedded training (ET) is required. Due to a recent $120 million cut in program monies, ET was not funded in the RDTE system for the baseline phase. The Joint Tactical Fusion Office is reportedly attempting to reinstate ET in the baseline phase (Ammon, 1985a; USAICS, 1983, 1984, 1985c).

1. ASAS Baseline System Unit Training

The contractor, Jet Propulsion Laboratory, will develop a complete operator training program during the baseline phase. This training will be transferred to a New Equipment Training Team (NETT) which will train the operators for the RDTE and limited procurement systems. Present plans call for contractor maintenance support at the unit, direct support, general support and depot levels until the objective system is fielded. Initial training of military maintenance personnel will be accomplished by the NETT with follow-on training conducted on-site by contractor maintenance personnel. Until fielding of the first objective phase system, all ASAS training will be conducted at the unit level (Alston, 1985; Ammon, 1985a; USAICS, 1983, 1984, 1985a, 1985c).

Unless funded, embedded training will not be a part of unit training in baseline ASAS systems. Unit training will consist of individual and unit training conducted during developmental and operational testing of the RDTE and limited procurement ASAS systems. Continuous testing and evaluation will have a major impact on the task analysis process reported on the Logistic Support Analysis Record (LSAR), a contract required procedure, which will have serious impact on the training community (Alston, 1985).

2. ASAS Objective System Unit Training

A Jet Propulsion Laboratory study on ASAS embedded training (NASA, JPL, 1984) defined ET planning and development efforts for the baseline ASAS/ENSCE system. The study results are also a basis for the expansion of ET for the objective system. The study developed four alternative ET training level programs which are discussed below.

a. Minimum Effective Program - $2,437,500

The minimum effective program would contain only the elements that would train operators and first line supervisors to utilize the full capability of the ASAS/ENSCE hardware and software. This program would include all man machine interface (MMI) operations, 16 hours of system orientation, all functional area unique requirements and 8 hours of collective/team training. No preventive maintenance checks and services (PMCS), troubleshooting and repair or staff training would be provided.

b. Basic Program - $2,700,000

The basic program would include all MMI tasks, 18 hours of system orientation and all PMCS tasks. Added to this would be all functional operating area requirements and 12 hours of collective/team training. No troubleshooting and repair training or staff training would be covered.

c. Enhanced Program - $5,610,600

The enhanced program would contain training on all MMI tasks, 27 hours of system orientation and all PMCS tasks. The program would also include all functional area unique training, 20 hours of reduced-scope collective/team training and 40 hours of reduced-scope staff training.

d. Super Enhanced Program - $8,535,600

The super enhanced ET program would include all MMI operations, 27 hours of system orientation training and all PMCS. The program would also include all of the requirements for functional area unique training, 40 hours of collective/team training and 80 hours of staff training.

UNIT TRAINING COSTS

Costs involved in unit training should be minimal. Individual training should involve no more than taking one system component off-line and loading the training software. Team/collective training would require similar conversion of two or more components to run a collective training exercise. Once the training was completed and feedback provided, the system would go back on-line or power down. Thus, garrison training costs would involve costs of generator fuel or commercial electrical power; field training would involve generator fuel costs only. In both cases the costs would be directly comparable to normal operating costs. Costs of computer operation would be minimal. Training software would be reusable.

Training system ownership costs must be included when considering the cost of unit training. Fixed scenarios have proven to be ineffective training tools in other systems, due to the lack of effect after several trials on a given scenario: once system operators learn the scenario, its effectiveness for sustainment training is greatly reduced. If some form of variable scenario development is not built into the system, then continuous scenario development, either in the unit or at USAICS, would be an ongoing cost and should be considered as a real part of the system software update costs.

SHIFT FROM TRAINING TO OPERATIONS MODE

Given the system hardware and software sophistication, this should be contained within a period of seconds to a few minutes.

TRAINING MANAGEMENT

While training system management has not yet been addressed for the ASAS system (for either the conventional or embedded training), the system possesses characteristics which should allow effective training management. Given computer memory capacity and disk storage capability, there is no reason why complete records of student, crew and unit performance could not be maintained on disk and available to the training manager(s) and to the ET software. Printer capability also allows for written records to be produced. Training supervisors at all levels could have the tools required to effectively manage the training requirement (NASA, JPL, 1984). It must be remembered that these have yet to be produced.

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

1. Equipment Availability

The ASAS components should be available for training purposes. When in the operational mode, 24 hour a day operation (USAICS, 1984, 1985a), a capability to conduct individual training still exists. There are periods of low activity when a component could receive permission to go off-line for training purposes and yet remain immediately available to go back on-line within a very short period. It would seem that the equipment would be even more available for training team/collective tasks when in garrison. Generally, availability of equipment should not be an impediment to training.

2. Soldier Availability

Soldier availability is usually the greatest impediment to training, especially in training team/collective tasks. While it is not a great problem to have an individual soldier available for training, it is usually difficult to have all the team players available at one time, in one place, for training collective tasks. Except for FTXs, collective training is seldom conducted. There is no reason to suggest that soldier availability will be lower for ASAS than for other combat support systems.

ADEQUACY OF TRAINING SYSTEM

The four levels of possible embedded training designed by the contractor provide a menu of training capabilities, with greater capability tied to greater costs.

Once a verified baseline task analysis has been conducted on the RDTE systems, an ET Minimum Effective Program could be developed that would be very adequate in meeting operational training needs if it were incorporated into the limited production (LP), limited capability systems. This ET program could then be refined, updated and enhanced for later applications.

A product improved ET package, based upon evaluation of the LP ET system, could then be developed for delivery with the objective systems. Such a two stage development process would insure a viable, effective training tool for unit sustainment training. An in-house (USAICS or unit) authoring capability should also be provided to allow for scenario development and to insure concurrent updating of the ET package with system software.

If the designed ET package or some close approximation is in fact implemented for ASAS, the resultant training should be adequate for unit sustainment training.

IMPEDIMENTS TO TRAINING

The ASAS a is very complex and effective system operation and is totally dependent on the concerted efforts of knowledgeable and skilled managers, communicators, analysts and maintainers. All are required to perform and interact effectively to produce the desired product at the desired time with the desired accuracy. All these aspects of system complexity indicate a great need for unit sustainment training. This has been recognized in system requirements documents and in the plans for development of embedded training. However, these documents do not indicate during which stage of system development embedded training will be initiated. Funding limitations during the baseline systems phase have eliminated a capability to develop ET with the RDTE system, although an attempt is being made to reinstate such funding. If ET funding is not available for the limited production systems, unit sustainment training will be extremely limited.

ASAS functions require a high degree of cognitive processing which requires frequent practice to sustain. The highly complex cognitive tasks required of analysts cannot be maintained at a high performance level if they are limited to practice only two to four times a year during field exercises. Research on human performance has strongly indicated that frequent practice is required to sustain proficiency in cognitive tasks. Without an efficient training program in ASAS to sustain operator/analyst performance, system capabilities could be degraded until such personnel become retrained on system tasks.

Embedded training is a requirement for the objective system. ET will then be available for unit sustainment training in the post-1990 period. The only perceived impediment to training would be in collective or whole task training. If the ET program does not incorporate an ability to simulate external system inputs, then training capability will be limited to individual or part task training. The inability to provide frequent collective training is an often heard remark in operational units. Collective training (of officers, warrant officers and enlisted personnel) will be limited in ASAS equipped units unless this capability is provided in an efficient ET program.

SUMMARY

ASAS is a tactical ADP system for Military Intelligence (MI). It has five main components: the forward sensor and interface control (FSIC) module; ASAS interface module (AIM); communications processing interface (CPI) module; intelligence data processing (IDP) module; and, the radio module (RAD). ASAS allows input of MI data and creation of large databases of assorted input from multiple sources. These data can then be automatically sorted, cataloged, prioritized, correlated, evaluated and critically analyzed by operator/analysts to create integrated files of processed data/information. Intelligence reports and graphic depictions of present and/or potential enemy activity can then be produced. This output provides the tactical commander with near real time, filtered intelligence information that can have a dramatic effect on battle conditions.

The system is being developed in two main phases. Both are to provide an operational capability to active divisions even while under development and test. The need for operational capability during the development and testing phase demands a sustainment training capability. This demand is not projected to be met due to present financial constraints. Embedded training (ET) was identified early as a means of efficiently meeting this sustainment training need, and ET is a required deliverable in the procurement contract. The contractor (JPL) has conducted a study to determine ET training requirements and costs. Four progressive level training programs, with increasing attendant costs, were recommended; however, no decisions have been made.

An ASAS training task analysis has been conducted based on the tasks identified by the Logistic Support Analysis process. This task list is rudimentary at this point because the RDTE system has yet to be fielded. Development of an effective ET system for ASAS that meets all the requirements of the operator/analyst will be an extremely difficult and demanding task. The operator/analyst's job involves fine discrimination, decision making and integrated performance skills, as well as knowledge of concepts, rules and principles to be applied to his choices. Building an ET system which successfully trains him to use the ADP capabilities of ASAS as an effective aid to these processes will also require a lengthy development period. A time that may not be available for ASAS due to resource constraints.

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APPENDIX H

HOWITZER IMPROVEMENT PROGRAM (HIP)

CONTENTS

CONTENTS (continued)

APPENDIX H

HOWITZER IMPROVEMENT PROGRAM (HIP)

WEAPON SYSTEM CHARACTERISTICS

1. Type of System:

Automated Self-Propelled Howitzer System (M109E5)

2. System Components:

The M109E5 Self-Propelled Howitzer (SPH) is an armored, full tracked howitzer which carries 36 rounds on board. It will be manned by a crew of five plus four on the Forward Area Ammunition Supply Vehicle (FAASV). The M109E5 will be equipped with a 155mm cannon. Three cannon configurations are under development: an improved M185/39 cannon; an M199 compatible cannon; and, an extended range cannon. The M109E5 will incorporate state-of-the-art technologies to achieve improved reliability, availability and maintainability (RAM). Built in test equipment (BITE), both diagnostic and prognostic, will be used. The crew will have benefit of an improved NBC protective system. A passive night vision device for the driver will facilitate movement and enhance survivability (US Army Field Artillery School [USAFAS], 1985a, 1985d).

a. Armament and Ammunition

The combination of cannon/breech, propellant, and projectile will permit an unassisted maximum range of 22 km and a maximum assisted range (e.g., via rocket assist or using the XM864 base bleed projectile) of approximately 30 km. Minimum range (high angle) will be 4 km. Ranges associated with the extended range cannon are currently classified (US Army Armament, Munitions and Chemical Command [USAAMCC], 1985; USAFAS, 1985d).

b. Fire Control

The M109E5 will incorporate an automated fire control system consisting of an inertial reference unit which provides accurate position location (northing, easting, and altitude) and azimuth reference, an on-board ballistic computer, and computer controlled gun drive servos. This combination will permit rapid emplacement/displacement tactics and dispersed positioning for semi-autonomous operations (USAAMCC, 1985; USAFAS, 1985d).

c. Command Control and Communications

An electronic suite incorporating digital data and voice communications systems will enable the use of on-board technical fire control and permit fire missions to be executed by any combination of artillery from one gun to multiple battalions. The use of mission dedicated guns or fire units will also be possible. Tactical fire control will be maintained through interface with the Battery Computer System (BCS) or the AFATDS fire support terminal. Communications will be secure. The communication system utilized will be

SINCGARS/VRC-89; although VRC-12 series radios may be substituted as alternate equipment. The Position Location Reference System (PLRS) may be added in the future (USAAMCC, 1985; USAFAS, 1985d).

d. Supporting Elements

The ammunition resupply vehicle will be the M992 Field Artillery Ammunition Supply Vehicle (FAASV). Some M548 ammunition carriers will also remain in the inventory. Each M109E5 will associate with either an M992 or M548 ammunition carrier (USAAMCC, 1985; USAFAS, 1985d).

e. Prime Mover

This is a self-propelled weapon system (USAAMCC, 1985; USAFAS, 1985d).

MISSION

The M109E5 Self-Propelled Howitzer has the specific mission of providing destructive artillery fires upon point and area targets in support of combat infantry and armor units. This weapon system is assigned to the heavy division, the heavy separate brigade, and the armored cavalry regiment as the close support artillery weapon system. The M109E5 will also be employed in the general support role as a weapon system for howitzer battalions of field artillery brigades attached to corps. The M109E5 will have the capability to function in a dispersed formation. An on-board, automated fire control system will permit the M109E5 to gain wider dispersion than in the past, fire their mission and move again, allowing greater defense against counter-battery fire. A semi-automatic ammunition loading system allows the HIP greater rates of fire than in the past, thus increasing firepower on the target (USAFAS, 1985d).

HISTORY OF SYSTEM ACQUISITION

The Howitzer Improvement Program was initiated to meet deficiencies identified in a Mission Area Analysis (MAA) and documented in a Mission Elements Need Statement (MENS) dated 12 December 1980. These specific deficiencies were (USAFAS, 1985d; McGinnis, 1985; Noble, 1985; Yanda, 1985) related to the lack of responsiveness, low RAM, inadequate terminal effects and inadequate survivability of the present system. Specific improvements demanded by the USAFAS were: imnproved survivability with semiautonomous operations; increased RAM (operationability of 75%); increased range; compatibility with the M203 charge; and, increased rate of fire to 6 rounds per minute.

The HIP is a follow-on program to the Howitzer Extended Life Program (HELP) which was initiated as a Product Improvement Program (PIP) to meet the short term needs of the Mission Essential Needs Statement (MENS). The HIP was initiated to meet the MENS long term objectives. HIP is presently in PHASE II of the LCSMM program (McGinnis, 1985).

A competitive procurement was announced on 16 February 1985 (DAAK10-85-R 0058) for the prototype development of three versions of this system and full

scale development to follow. Proposals were still being considered as of our visit (26 June 1985); but it is understood that the contract was awarded in July 1985. Production procurement is expected in 3Q FY86 and fielding anticipated in 4Q FY88 (USAAMCC, 1985; Garcia, 1985).

PERSONNEL AND KEY JOB TASKS

The personnel requirements recommended by the HARDMAN study are listed in Table H-1 (Mannie & Risser, 1982).

Table H-1

Recommended Personnel to Support HIP

MOSC	Grade	Number	Title	Duties
13B30	E6	1	Gun Chief	Supervise gun crew operations Perform manual laying of the gun when required
13B20	E5	1	Gunner	Operate fire control system Monitor/relay and record fire commands Operate communications system Manually set cannon azimuth and elevation controls when necessary
13B10	E4	1	Assistant Gunner	Assist gunner in his tasks Perform gunner tasks in absence of gunner
13B10	E4	1	M109E5 Driver/ Cannoneer	Drive M109E5 Operate communications system
13B10	E3	1	Cannoneer/ Ammunition Handler	Operate ammunition loader Assemble various on-board munitions Operate communications system

SYSTEM DISPLAYS, INDICATORS AND CONTROLS

The specifics of major information displays are unknown at this time. However, the SOW (USAAMCC, 1985) and the HIP User Interface Requirements (USAFAS, Undated) indicate that the fire control operator's console might have a graphic display capability for graphically depicting such things as the

location of other howitzers, the platoon FDC and the portrayal of a simple strip map. It must, as a minimum, be capable of displaying the complete information of a fire mission on one screen. Operators will interact with the system through an input device that is as yet undetermined, but probably will be a membrane switch keyboard capable of alphanumeric data input. Other controls and indicators are anticipated to be those usually found on standard, militarized, electronic equipment. The AFCS's Inertial Reference and Navigation System (IR/NS) and Modular Azimuth Positioning System (MAPS) (when available) shall also display information on the display panel, similar to the MLRS's SPLL Fire Direction Console. The operational system software shall be primarily menu driven and will enable the operator to select a given function and lead him through the proper sequence of operations with display prompting for maximum user-friendliness. Improper operator entries to prompts shall be locked out and error notification shall be provided by means of an audible and visual alert (USAFAS, Undated).

COMPUTER CAPABILITIES

HIP's computer capacity is unknown at this time. However, the SOW clearly indicates that the computer RAM will have at least a 50% reserve capacity over system operational software requirements. Present standards (DOD-STD-1467 and DOD-STD-1679) only require a 20% reserve capacity. This 50% reserve capacity should allow maximum utilization of embedded training software which is required by the SOW. The extent and nature of the embedded training software requirement is to be clarified in the 90-day contract definition phase immediately following contract award (USAAMCC, 1985; Garcia, 1985; McGinnis, 1985).

EQUIPMENT SIMULATION OF KEY COMBAT TASKS FOR TRAINING AND TESTING

Given the additional memory planned for the computer system and the fact that system displays provide all of the information during combat, HIP should provide a large capacity to simulate key combat tasks (USAAMCC, 1985; Garcia, 1985; McGinnis, 1985).

PROVISION OF ACCURATE FEEDBACK ON OPERATOR/MAINTAINER/TEAM PERFORMANCE DURING OPERATIONAL AND TRAINING USE

1. Operational System Feedback

Operational operator/team performance feedback is provided by forward observers (FO) as to accuracy of fire. Individual performance feedback is provided by the Gun Chief Supervisor through observation. Maintainer performance feedback is also provided through supervisor observation. The only system feedback provided is when the operator exceeds parameter limits of menu driven inputs on the Fire Direction Computer, at which time audio-visual cues are provided (USAAMCC, 1985; USAFAS, Undated).

2. Training System Feedback

Computer capacity planned for the system indicates that the capacity to provide accurate performance feedback should be large (USAAMCC, 1985). The embedded training system could include sophisticated features such as adaptive testing, networking for simultaneous training of multiple personnel or multiple teams, etc.

CHARACTERISTICS OF INSTITUTIONAL AND UNIT TRAINING

Existing operator institutional training will be modified to include fire control systems operation. This will be aided by a fire control system training device. Operator unit sustainment training will be conducted with the assistance of embedded training to be developed by the HIP contractor. The PM-TRADE has conducted a study and recommended two ET options: an embedded software system for use in one weapon system and a strap-on device that is capable of simultaneously training up to four weapon systems.

Existing maintainer institutional training presently includes a maintenance simulator for subsystem maintenance training. A HIP specific training device is under development to provide HIP subsystem specific training. This training device will be located in those TRADOC schools providing HIP subsystem maintenance training.

EXISTING/PROPOSED INSTITUTIONAL TRAINING

The HARDMAN study (Mannie & Risser, 1982) indicated that an attempt was made to determine specific training media for specific tasks, however, this could not be accomplished due to a lack of policy guidelines concerning media selection. A Training Device Study conducted by Army PM-TRADE (USAAMCC, 1985), described three potential training systems. One was an embedded training system with two strap-on options: one to train an individual howitzer, the other to simultaneously train a howitzer platoon. The other two proposed systems were institutional training devices: a HIP Institutional Fire Control System Trainer and a HIP Institutional Maintenance Trainer.

The HARDMAN study (USAAMCC, 1985) also indicated that with the exception of the Fire Control Operator/Gunner, very few major changes to existing training courses were anticipated. Several minor changes were envisioned in existing crew training requirements.

The courses planned at the US Army Field Artillery School (USAFAS) as resident courses for HIP operators and maintainers are shown in Table H-2 (USAFAS, 1985a, 1985b).

Skill level 13B20 is trained through supervised-on-the-job-training (SOJT) and attendance at a 4 week Primary Leadership Development Course conducted in major posts and commands worldwide. This is strictly a generic NCO training course (USAFAS, 1985b).

Table H-2

Courses Planned for HIP

Course	Length	MOS/ASI
a. 13B-OSUT/041-13B10-AIT FA Cannon Crewman	5 weeks	13B10
Present training focuses on the duties of soldiers in a field artillery howitzer section which includes identification of howitzers and ammunition, techniques for handling ammunition, setting fuzes, preparing charges, loading and firing howitzers, and maintenance. When skill level 1 personnel are identified for assignment to self-propelled or towed Howitzer units, instruction is tailored to their respective weapon system.		
b. 45D10/20 Self-Propelled Field Artillery Turret Mechanic	4.8 weeks	45D10
Training focuses on servicing, lubricating, removal, installation, repair, adjustments, purges, and testing of carriage mounted armament, sighting and fire control assemblies, electrical systems, and the cab of turrets on self-propelled artillery systems.		

Skill level 13B30 is trained through SOJT and attendance at a major command Basic Noncommissioned Officer Course (BNCOC) of 5 weeks duration following a 13B30 Program Of Instruction provided by USAFAS. This is strictly a generic NCO training course (USAFAS, 1985b). Skill level 13B40 is trained through SOJT and attendance at the 14 week and 2 day Field Artillery Cannon Advanced NCO Course (FACANCO). This course length will increase to 15 weeks and 4 days, in 4Q FY86 due to new systems instruction. This course is conducted at Fort Sill and has an initial generic track. Students are then broken out into separate tracks according to their specific MOSs (USAFAS, 1985b).

There are seventeen maintenance MOSs involved with the present M109 SP Howitzer. Each maintainer is involved with a specific subsystem of the overall system (e.g. - turret, fuel, electrical, automotive, fire control, radio, NBC, etc.). The 45D is the primary maintainer for the gun and fire control system of the HIP (Department of the Army [DA], 1985; Mannie & Risser, 1982; USAAMCC, 1985).

No reduction in maintenance personnel is envisioned for the HIP. Few task changes are foreseen for system maintainers. The addition of an automated

BITE capability and LRU engineered construction will, in some cases, reduce troubleshooting and replacement tasks (Mannie & Risser, 1982).

Proposed institutional training and any institutional training devices are to be contractor developed (USAAMCC, 1985).

A HIP Training Devices Preliminary Concept Formulation Package was prepared by PM-TRADE, dated 8 March 1985 (US Army Material Command [AMC], 1985). This document lists the origin of the training device requirement as the HIP Draft O&O Plan, dated 15 January 1985, and the Program Management Document (PMD), Section V, Integrated Logistics Support Plan (ILSP) for the HIP, dated March 1985 (USAAMCC, 1985).

1. <u>HIP Institutional Fire Control System Trainer</u>

This simulator will provide initial entry and skill proficiency training for the cannon crewman MOS (13B10) at the USAFAS. This device shall be used to familiarize 13B students with the operational capabilities of the HIP electronics and communication system. BIT and BITE procedures shall be trained. It will also provide practice on all fire control system tasks involved in the conduct of a direct or indirect fire mission, including performance under degraded conditions (USAAMCC, 1985).

The device is described as consisting of an instructor station and 25 trainee stations consisting of a Section Chief Display Control Unit (SCDCU) panel for each station. This panel is required to contain an exact duplication of the functional controls and displays on the operational HIP. The device will be capable of being computer- or instructor-controlled. In the computer-controlled mode, it shall be capable of: adaptive lesson and scenario presentation; malfunction insertion; cues and prompts including demonstration; performance feedback; and, performance testing. The instructor-controlled mode shall contain options for instructor selection of: objectives; control of parameters; scenario pacing; selection of malfunctions, cues, prompts and demonstration; and, performance feedback. The device should be transportable in a 2 1/2 ton truck and be capable of CONUS/OCONUS operation (USAAMCC, 1985).

2. <u>HIP Institutional Maintenance Trainer</u>

The primary purpose of this trainer is to provide training in theory, function, troubleshooting and preventive maintenance of the automotive, armament and electronic subsystems of the HIP.

The present Field Artillery Turret Maintenance Trainer (FATMT) is to serve as the basis for further development of a similar HIP Institutional Maintenance Trainer. According to PM-TRADE's training device study, the Army is presently soliciting, under separate contract, proposals to develop, fabricate and procure 7 FATMTs with an option to procure an additional 15 to support MOS 45D training. These projected training devices are envisioned to consist of computer driven subsystem panels, mock-ups and lowest replaceable units (LRU) (USAAMCC, 1985).

A total of four FATMTs are planned for Fort Sill MOS 45D HIP specific training, and the remainder to support maintenance training for the other 16 maintenance MOSs located at other TRADOC schools (USAAMCC, 1985).

EXISTING/PROPOSED UNIT TRAINING

Embedded training is identified in the SOW as a deliverable. The contractor is required to design, develop and integrate ET in support of unit training plans. A contract was recently awarded to Applied Science Associates, Valencia, PA, to perform an independent evaluation of the ET requirements for HIP to assist in the development of the ET package (Personal communication, Dr. S. Burroughs, Army Research Institute, 2 August 1985).

The Training Device Study conducted by PM-TRADE recommended two embedded training options. Option 1 called for incorporation of hardware and software within the operational system that will "stimulate" the operational systems, providing feedback and measurement capability on operational system displays (AMC, 1985).

Option 2 called for the management and "stimulation" of operational systems by means of a strap-on ET system. There are two potential subsets of this option. One relates to an ET system for one HIP, and the other relates to an ET system with an instructor station and the simultaneous networking of up to four HIPs (AMC, 1985).

Both options are to provide training in indirect and direct fire tasks under normal and degraded conditions. ET is to provide automated lesson presentation to include: parameter freeze and restart; scenario freeze and restart; malfunction insertion; cues and prompts; performance feedback; and, automated performance monitoring, scoring, and recordkeeping (AMC, 1985).

The contractor is to make a determination, after Operational Testing (date unknown), which option is the most suitable for the HIP, and produce an ET package (AMC, 1985).

UNIT TRAINING COSTS

Considering the range limitations at most installations, many Field Artillery Battalions must relocate to installations having ranges with sufficient distance available in which to actually fire their weapons. In addition, training ammunition allocations have in recent years been very sparse due to increasing costs. CONUS units are unable to train in firing "smart" munitions due to limited production and their present limited CONUS availability (Yanda, 1985).

These conditions do not auger well for training of Field Artillery assets. Training in the FA is a very expensive proposition. Units must be moved quite some distance, generally by train; they must fire expensive ammunition in limited quantities; then be transported back to their home station, again by train.

Although no specific training costs are available, it would not be unreasonable to expect annual training costs to be in the millions of dollars for the proposed 43 1/3 HIP FA battalions (USAFAS, 1985d). The implementation of embedded training could dramatically reduce training costs. There is an expectation of rotating all active duty FA battalions through the National Training Center (NTC) on an 18-month schedule. With an embedded training capability, that may be the only actual firing experience that is needed to maintain operational readiness. However, that has yet to be proven.

SHIFT FROM TRAINING TO OPERATIONS MODE

This issue has not been addressed in any of the publications examined to date. Assuming proper hardware and software configurations, this should not present a problem.

TRAINING MANAGEMENT

A requirement exists in the PM-TRADE Training Device Study (AMC, 1985), which is the guide for the prime contractor, that a training management capability be built into the embedded training package - regardless of the final option chosen (USAAMCC, 1985). This capability consists of monitoring, scoring, and recordkeeping. There does not appear to be any requirement for providing hardcopy results, (e.g.- a printer) nor does the HIP appear to have such capability (USAFAS, Undated).

A handwritten hardcopy of training results could be copied from the system displays and used in training management; but inclusion of a printer output would be more useful and probably more used.

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING

Availability of equipment for training does not appear to present a problem. The prime equipment will usually be located in a motor park when not actually required for operations. Considerable amounts of time are spent on preventive and scheduled maintenance of the prime equipment. Availability of personnel may present some problems in team training due to an inability to assemble all team members at one time. However, individual training should not be a problem. As with all units, the commander's emphasis on training will play an important part in availability of personnel and equipment (Author's personal experience).

ADEQUACY OF TRAINING SYSTEM

The prime operational mission of the HIP is to produce direct and indirect fires upon the enemy. These are also the primary tasks supported by the embedded training system. Excellent guidance has been provided by the PM-TRADE training device study; professional guidance is anticipated from the TSM's representative; and testing of the ET system will be conducted via the

Operational Test. There does not appear to be any reason why the final ET system will not meet existing operational needs.

IMPEDIMENTS TO TRAINING

One can only project at this point what impediments to training may exist for this developing system.

The lack of anything other than a keypad for inputting information to the computer may require strap-on devices for the embedded training package. System designers might wish to modify the limited input capability planned for HIP. A more flexible input capability may provide benefits in addition to exportable training.

Discussions with users of other developing systems indicate a reluctance to provide an objective evaluation capability to the field. It has been stated that there is such a diverse range of subjective evaluations in the field that the expense of providing an objective evaluation capability is not cost-effective. Of course, there may also be a reluctance to train to a baseline objective requirement that could evaluate a commander's performance. This reluctance to accept an objective scoring capability has been noted in Navy ET systems for the same reason (Personal communication, Mr. Ken Muse, NTEC, Orlando, FL, 30 April 1985).

SUMMARY

The Howitzer Improvement Program (HIP) is the second phase of a Pre-Planned Product Improvement Program (P3I) for the M109 Self-Propelled Howitzer. The first phase is called the Howitzer Extended Life Program (HELP) and is intended to improve certain aspects of the present howitzer. The HIP is intended to automate fire control, gun laying procedures, ammunition loading, and further upgrade howitzer functions covered in the HELP.

Systems implemented for the HIP include computerized fire control with servomotor controlled gun laying functions. These functions will lay the gun tube in the correct angle and azimuth to provide an accurate ballistic trajectory to a fired round so that it lands where intended. There are also automatic functions that load the correct round with correct powder charge for the demanded fire mission. There is also a computerized position locating system, similar to the Multiple Launch Rocket System, that can determine the gun's correct position and feed that data into the ballistic algorithm.

A contract to produce five developmental systems with follow-on full scale production was awarded in July 1985. This contract included the development and production of embedded training for the HIP. A Training Device Concept Formulation Package (AMC, 1985) recommended two operator ET options and two training devices. These recommendations were included in the contract Statement of Work (SOW) and are contract deliverables.

The following active elements in the HIP programs past, present and future, are perceived as being influential in producing a viable ET product for the HIP:

The requirement for ET was included in the Organizational & Operational Plan, the MENS and/or the ROC;

The early HARDMAN study contributed to the definition of the need;

A training device study outlining hardware and software requirements, was conducted by specialists (PM-TRADE); and,

ET was included in the prime contract with a requirement to use the PM-TRADE training device study as a required reference and standard.

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APPENDIX I

INTERVIEW GUIDE FOR ARMY SYSTEM DATA COLLECTION

WEAPON SYSTEM CHARACTERISTICS

1. What are the major system components?____________________________________

____

____

2. Describe the equipment and its configuration.___________________________

____

____

3. Are training devices available at the unit? YES_____ NO_____
4. If "YES", how many? ______ What type? ___________________________________

____

5. Is other special equipment available to facilitate training on the job? YES_____ NO_____
6. If "YES" describe this special training equipment.______________________

____

____

MISSION

1. What is the primary combat mission?_______________________________________

____

2. What are other combat missions?____

____

____

3. How does training with the equipment occur?_______________________________

____

____

4. Is the equipment used for other non-combat purposes? YES_____ NO_____
5. If "YES" describe ____

____

____

PERSONNEL

1. For each <u>OPERATOR</u> MOS/skill-level assigned to the system, give the number of personnel assigned to one system, the critical job tasks this MOS/skill-level person performs, and the location(s) where this task is trained.

SKILL			TRAINING SITE			
MOS	LEVEL	NO.	CRITICAL JOB TASKS	SCH.	UNIT	BOTH

2. For each OTHER MOS/skill-level assigned to the system, give the number of personnel assigned to one system, ONE OR TWO MAJOR job tasks that this MOS/-skill-level person performs, and the location(s) where this task is trained.

MOS	SKILL LEVEL	NO.	MAJOR JOB TASK	TRAINING SITE SCH.	UNIT	BOTH
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____
____	____	____	____________________	____	____	____

3. How many enlisted personnel are assigned to this system throughout the Army?__________

NATURE OF SYSTEM DISPLAYS, INDICATORS AND CONTROLS

1. Is the system used to engage targets or process target information? YES_____ NO_____ If "NO" skip to Question 10.
2. Are enemy targets viewed directly? YES_____ NO_____
3. Are targets viewed through an optical sight? YES_____ NO_____
4. Are targets indicated on a radar display? YES_____ NO_____
5. Are targets indicated on another type of Cathode Ray Tube (CRT)? YES_____ NO_____
6. Are targets indicated on a liquid crystal display? YES_____ NO_____
7. Are targets indicated on a Light Emitting Diode display? YES_____ NO_____
8. Is any target information presented on headphones, telephone or other sound source? YES_____ NO_____
9. Is target information presented on some other type display? YES_____ NO_____ Describe the display(s)____
____
10. Does the system include a vehicle of some type? YES_____ NO_____ If "NO" skip to Question 15.
11. Does the driver/pilot view the terrain directly? YES_____ NO_____
12. Does the driver/pilot view the terrain through a periscope? YES_____ NO_____
13. Does the driver/pilot view terrain on a video CRT? YES_____ NO_____
14. Does the driver/pilot obtain auditory information via radio, etc.? YES_____ NO_____
15. Is any system information other than targets presented on a CRT? YES_____ NO_____
16. Is any system information other than targets presented on an LED or liquid crystal digital display? YES_____ NO_____
17. Is system information other than targets presented on headphones, telephone or other speaker? YES_____ NO_____
18. Describe any special displays that exist for training and/or testing of personnel____
____
____
19. Describe any other displays monitored by the operator or other personnel and their purpose.____
____

20. Check the following controls or other input devices if they are used in the system. Describe the major function.
trigger_____ used to____
joystick _____ used to____
steering wheel_____ used to____
trackball_____ used to____
pushbutton _____ used to____
keyboard _____ used to____
keypad_____ used to____
toggle switches_____ used to____
knobs_____ used to____

21. Describe any special controls or other input devices that exist for training and/or testing of personnel____

22. Describe any other controls or input devices and their use____

COMPUTER CAPABILITIES

1. Is there at least one microprocessor or computer in the system? YES_____ NO_____ (If "NO" skip to next section).
2. Type of display? Monochrome CRT_____, Color CRT_____, Liquid Crystal_____, Other_____ (describe)____
3. Type of processor _______________
4. How much RAM? _______K bytes.
5. How much RAM in addition to operational requirements?____________K bytes.
6. Can additional RAM be added? YES_____ NO_____
7. Check available peripherals/equipment and provide capacities as requested. Printer_____. Floppy disk drive_____. Hard disk drive______--Capacity _________megabytes. Magnetic tape_____. Keyboard______. Keypad______. Modem______.
8. What function(s) does the computer perform during an operational mission?
____

9. Can the system computer currently be used for any purposes other than the operational mission? YES_____ NO_____(If "NO" skip to next section).

CAN THE COMPUTER SYSTEM BE USED FOR ANY OF THE FOLLOWING:

10. Training of operator skills? YES_____ NO_____
11. Full-simulation of combat environment for operator training? YES_____ NO_____
12. Part-simulation of combat environment for operator training? YES_____ NO_____
13. CAI or CBI? YES_____ NO_____
14. Training of maintainer skills? YES_____ NO_____
15. Training of team skills? YES_____ NO_____
16. Other training? YES_____ NO_____ If "yes" please describe
____

17. Testing of operator skills? YES_____ NO_____
18. Testing of maintainer skills? YES_____ NO_____

19. Testing of team skills? YES____ NO____
20. Training Management? YES____ NO____
21. Inventories? YES____ NO____
22. Games? YES____ NO____
23. What else?____

EQUIPMENT SIMULATION OF KEY COMBAT TASKS

1. Will the operator be required to respond to more or different sights, displays, and/or sounds during during actual combat which he does not encounter during peacetime uses of the system? YES____ NO____
2. Describe these. ____

3. Will the operator make different responses, faster responses, and/or more responses during combat than he does in peacetime operation of the system? YES____ NO____
4. Describe these. ____

5. Is the system capable of simulating these unique combat conditions? YES____ NO____ IF "NO" SKIP TO NEXT SECTION.
6. How accurately are these conditions simulated? HIGH____ MEDIUM____ LOW____
7. Is this simulation capability used for training operators or teams? YES____ NO____
8. Is this simulation capability used to demonstrate system operation? YES____ NO____
9. Is this simulation capability used to assist maintainance personnel in checking out the system? YES____ NO____
10. Does this simulation of combat vary from one presentation to the next (not the same few scenarios over and over again)? YES____ NO____
11. What could be added to the system to increase the capacity to simulate combat stimuli and responses?____

PROVISION OF ACCURATE FEEDBACK ON PERFORMANCE

1. How accurate is the information that operators and/or maintainers have about their own performance? HIGH____ MEDIUM____ LOW____
2. How accurate is the information that supervisors have of the performance of these personnel? HIGH____ MEDIUM____ LOW____
3. Can individual performance of operator tasks be tested on the system equipment? YES____ NO____
4. If "YES", how often is each operator tested per year?________
5. What other means are used to evaluate operator skills and knowledges?
____

6. For what purposes are operator skills and knowledges evaluated? READINESS ASSESSMENT/MAINTENANCE____ TRAINING MANAGEMENT____ INDIVIDUAL ADVANCEMENT____ OTHER ________________________________
7. Can performance of maintenance tasks be tested on the system equipment? YES____ NO____

8. If "YES", how often is each maintainer tested per year?_________

9. What other means are used to evaluate skills and knowledges of maintain ers?____

____

____

10. For what purposes are maintainer skills and knowledges evaluated? READINESS ASSESSMENT/MAINTENANCE_____ TRAINING MANAGEMENT_____ INDIVIDUAL ADVANCEMENT_____ OTHER ____

11. Can team performance be tested on the system equipment? YES_____ NO_____

12. If "YES", how often is each team tested per year?_________

13. What other means are used to evaluate team skills?___________________

____

____

____

14. For what purposes are team skills evaluated? READINESS ASSESSMENT/MAINTENANCE_____ TRAINING MANAGEMENT_____ OTHER __________

____

15. How accurately (validly) do the tests measure skills? HIGH VALIDITY_____ MODERATE VALIDITY_____LOW VALIDITY_____

16. Do the tests change on successive administrations to cover the range of operational situations? YES_____ NO_____

17. Are tests of operator or team performance administered on the equipment automatically? YES_____ NO_____

18. Are these tests scored automatically? YES_____ NO_____

19. Is adaptive testing used (item difficulties automatically concentrated at testee ability level)? YES_____ NO_____

20. Are test data recorded? YES_____ NO_____

21. Are test data cumulated (for teams, unit, etc.)? YES_____ NO_____

22. How are recorded test data used?______________________________________

____

CHARACTERISTICS OF INSTITUTIONAL TRAINING

1. What MOS's are used , or anticipated to be used, by the system?

____

____

2. How many training hours are in each MOS-specific formal course of instruction? How do these hours breakdown for classroom training, hands-on trainng with the equipment and training in simulators?

MOS	TOTAL TRNG. HRS.	HRS. IN CLASSROOM	HRS. ON EQUIPMENT	HRS. ON SIMULATOR

3. For each MOS school course, on the average, how many students are programmed for each class? How many students graduate each year? What is the average real attrition rate for academic failure in each course? What is the average instructor/student ratio?

COURSE	MOS	CLASS SIZE	ANNUAL THROUGHPUT	FAILURE RATE	INSTRUCTOR/ STUDENT RATIO

4. What training devices or simulators are used to train which actual pieces of equipment?

TRAINING DEVICE OR SIMULATOR	ACTUAL EQUIPMENT SIMULATED

5. In your opinion, what tasks are not trained to an acceptable level of performance?____

6. For each of these tasks describe what changes in training would be required for acceptable trainee performance.

TASK NUMBER	TRAINING CHANGES NEEDED

7. What tasks should be added to school training?____________________

8. What tasks should be dropped from school training?____________________

9. Are there enough training materials to meet training needs? YES_____ NO_____

10. Are training materials adequate to meet training needs? YES_____ NO_____

11. Discuss problems with training materials and possible solutions.

CHARACTERISTICS OF THE UNIT TRAINING SYSTEM

1. Was refresher training and/or other post-school training considered during system development (ICTP, Other) YES_____ NO_____ IF "NO" GO TO QUESTION 7.

2. At what point in the system development process was "job-site training" considered?____

3. What determined these original job-site training requirements and procedures?____

4. Was embedded training (hardware, software and/or courseware developed to provide training on the job) an option that was considered? YES_____ NO_____
5. If "YES", was embedded training implemented? YES_____ NO_____
6. If "NO", why not?____

7. If embedded training was implemented, how were computers, displays and controls of the operational system redesigned or modified to accommodate the embedded training system?____

8. How have operational requirements influenced job-site training?

DESCRIPTION OF EXISTING JOB-SITE TRAINING

1. Do school graduates require on-the-job training of new SKILLS to operate the system? YES_____ NO_____
2. What are the major new operator skills trained at the job-site?__________

3. Describe this training of new skills (equipment, other media, personnel involved, testing, etc.)____

4. Do school graduates need to obtain new KNOWLEDGE on the job to operate the system? YES_____ NO_____
5. What are the major new operator knowledges trained at the job-site?_____

6. Describe this training of new knowledge (equipment, other media, personnel involved, testing, etc.)____

7. Do operator personnel require refresher training and/or practice on the job to successfully operate the system? YES_____ NO_____
8. What are the major operator skills and knowledges that require such refresher training and/or practice?____

9. How frequently SHOULD job-site refresher training occur for key operator skills? DAILY_____, EVERY OTHER DAY_____, WEEKLY_____, MONTHLY_____, OTHER____
10. How frequently DOES refresher training occur for these key operator - skills? DAILY_____, EVERY OTHER DAY_____, WEEKLY_____, MONTHLY_____, OTHER____
11. Describe this refesher training and/or practice (equipment, other media, personnel involved, testing, etc.)____

12. On the average, how many hours of training occur per month for each operator?______ hours
13. How is this training time distributed over major operator skills and knowledges? ____
____

4. On the average, how much of this training time is spent in the training of new operator skills and knowledges? _____ hours
15. On the average, how much of this training time is spent in closely supervised practice of existing operator skills? _____ hours
16. On the average, how much of this training time is spent in largely unsupervised practice of existing operator skills? _____ hours
17. On the average, how much of this training is team training? _____ hours
18a. How long is a typical new skills training session for operators?____ hours
18b. How long is a typical refresher training session for operators?_____ hours
19. Do maintainance school graduates require additional skill training on the job to maintain the system? YES_____ NO_____
20. Do maintainance school graduates require additional knowledge training on the job to maintain the system? YES_____ NO_____
21. Is on-the-job refresher training and practice necessary for soldiers to maintain their competence to maintain the system? YES_____ NO_____
22. On the average, how many hours of training occur per month for the average maintainer?_____ hours
23. On the average, how is this time distributed over major maintainer tasks?____
____

24. Describe this maintenance training (equipment, other media, personnel involved, testing, etc.)____
____

25. On the average, how much of this time is spent in training new maintenance skills and knowledge? ______ hours
26. On the average, how much of this time is spent in closely supervised practice of existing maintenance skills? _____ hours
27. On the average, how much of this time is spent in largely unsupervised practice of existing maintenance skills? _____ hours
28. How long is a typical training session for maintainers?_____ hours
29. On the average, how many hours of training occur per month for the average TEAM of operators?______ hours
30. On the average, how is this time distributed over major team tasks?
____
____

31. Describe this team training (equipment, other media, personnel involved, testing, etc.)____
____

32. On the average, how much of this time is spent in training new team skills?______ hours
33. On the average, how much of this time is spent in closely supervised practice of existing team skills? _____ hours
34. On the average, how much of this time is spent in largely unsupervised practice of existing team skills? _____ hours
35. How long is a typical training session for teams?_____ hours
36. Can an individual practice his part of team tasks without other team members being present? YES_____ NO_____

37. Does cross-training occur? YES_____ NO_____ For whom? ____________________

____

38. Describe this cross-training (equipment, other media, personnel in volved, testing, etc.)____

____

39. Does part-task training of skills occur? YES_____ NO_____
40. Does whole-scenario training of skills occur? YES_____ NO_____
41. Does testing occur prior to training? YES_____ NO_____
42. Does testing prior to training determine content and/or level of training? YES_____ NO_____
43. Does testing occur during training? YES_____ NO_____
44. Does testing occur following training? YES_____ NO_____
45. Does computer-assisted training occur? YES_____ NO_____
46. Which of the following other training strategies and techniques are used? TEC-LESSONS_____ WORKBOOKS_____ LECTURES_____ FILMS________ VIDEO TAPES_____ ANYTHING ELSE?______________________________________

____

47. What proportion of personnel training goes for non-system training such as security, drug abuse, UCMJ, etc.?________________________________

____

48. Are unit personnel ever sent from the unit to another location for system-related training? YES_____ NO_____
49. If "YES", where? ______________________________
50. What skills and knowledges are trained at these other locations?________

____

UNIT TRAINING COSTS

1. Are there special pieces of equipment that are used for unit training of operators and other personnel? YES_____ NO_____
2. What was the initial cost for all systems of this special unit training equipment? $__________
3. What is the annual cost for replacement parts for this training equipment for all systems? $__________
4. Is ammunition used during unit training? YES_____ NO_____
5. What is the annual cost of ammunition used for unit training for all of these systems? $__________
6. Is gasoline or diesel fuel used during unit training? YES_____ NO_____
7. What is the annual cost of fuel for unit training for all of these systems? $__________
8. Is there severe wear and tear on equipment during unit training? YES_____ NO_____
9. What portions of the equipment wear out or are damaged by using the system for unit training?____________________________________

____

10. Does training-induced wear of the equipment reduce operational readiness? YES_____ NO_____
11. Does training use of the equipment help locate equipment problems and increase readiness? YES_____ NO_____
12. What is the annual cost of equipment maintenance and repair that is associated with unit training for all of these systems? $__________

13. How many extra personnel are needed at the unit to supervise and provide training? __________

14. What is the annual cost of these extra personnel required for unit training for all of these systems? $__________

15. Are personnel ever injured during training use of the equipment? YES_____ NO_____

16. What is the annual cost of these injuries and lost personnel time as a result of training for all of these systems? $__________

SHIFT FROM TRAINING TO OPERATIONAL MODE

1. Are there separate modes or configurations for operational use of the equipment and use of the equipment for unit training? YES_____ NO_____ IF "NO", SKIP TO NEXT SECTION.
2. Does the appearance of the equipment, displays or controls differ in the training mode from their appearance in the operational mode? YES_____ NO_____ IF "NO" GO TO QUESTION 5.
3. Do such differences reduce the effectiveness of training? YES_____ NO_____
4. Were any of these differences actually planned to facilitate or improve training? YES_____ NO_____
5. How difficult is it to switch from the training mode to the operational mode? EXTREMELY DIFFICULT_____ DIFFICULT_____ NOT DIFFICULT_______
6. How much time does it take to switch from the training mode to the operational mode? ______ minutes
7. Does the delay/difficulty of the shift from training mode to operational mode have serious consequences for operational readiness? YES_____ NO_____
8. How difficult is it to switch from the operational mode to the training mode? EXTREMELY DIFFICULT_____ DIFFICULT_____ NOT DIFFICULT_______
9. How much time does it take to switch from the operational mode to the training mode? _______ minutes
10. Does time or trouble in this switch from operational to training modes impede training? YES_____ NO_____

TRAINING MANAGEMENT

1. Who is primarily responsible for scheduling unit training on the system? ___________________ who schedules approximately _____% of operator training.
2. What percentage of operator training is scheduled by the Commander _____%
3. Do operators recognize their deficiencies and initiate training? YES_____ NO_____ IF "YES" what percentage of operator training is scheduled by these trainees? _____%
4. Who insures that scheduled training occurs?____________________________
5. What training data are recorded?____________________________
6. How is trainee progress fed back to the trainee?____________________________
7. How is training/assessment data used?____________________________
8. Do periodic readiness inspections or other unit tests influence the amount of training that occurs? YES_____ NO_____

AVAILABILITY OF EQUIPMENT/SOLDIERS FOR TRAINING AND TESTING

1. What priority does training use of equipment have relative to other uses?
HIGHEST_____ INTERMEDIATE_____ LOW_____ LOWEST_______
2, How available is the equipment for training and/or testing of personnel?
ALWAYS_____ USUALLY_____ SOMETIMES_____ SELDOM_____ NEVER_____
3. When is the equipment available?______________________________________
4. On the average how many hours per week?______________________________
5. When and how long is the equipment down for maintainance?
____
6. How often is the equipment out of service because of equipment failures?
FREQUENTLY_____ OCCASIONALLY_____ RARELY________
7. How often is the equipment purposely shut down to conserve power, prevent wear-out, or for other reasons? FREQUENTLY_____ OCCASIONALLY_____
RARELY_________ For what reasons?____
8. How often is operator training or team training interrupted?
FREQUENTLY_____ OCCASIONALLY_____ RARELY________For what reasons (in order of importance)?____
10. How available are soldiers for training? HIGH AVAILABITY_____ MODERATE AVAILABILITY_____ LOW AVAILABILITY_____
11. What are the major reasons when soldiers are not available (in order of importance)?____

ADEQUACY OF TRAINING SYSTEM

1. Rate the readiness of your unit. MORE THAN ADEQUATE TO MEET THE THREAT _____ ADEQUATE TO MEET THE THREAT_____ LESS THAN ADEQUATE TO MEET THE THREAT_____ MUCH LESS THAN ADEQUATE TO MEET THE THREAT
2. What primarily limits the performance of the system? EQUIPMENT LIMITATIONS_____ NATURAL TALENT OF PERSONNEL_____ INADEQUATE SCHOOL TRAINING OF PERSONNEL_____ INADEQUATE TRAINING OF PERSONNEL ON THE JOB_____ OTHER ______
(EXPLAIN "OTHER")____
3. How much training do personnel receive on the job compared to the amount needed to perform their jobs adequately? TOO MUCH_____ APPROPRIATE AMOUNT _____ SOMEWHAT LESS THAN NEEDED_____ MUCH LESS THAN NEEDED_____
4. Does refresher training occur frequently enough to maintain important skills at high levels? YES_____ NO_____
5. Can individual differences in operator performance be trained away?
YES_____ NO_____
6. Do any important skills or knowledges decline following assignment to the unit? YES_____ NO_____
7. If "YES", describe.____
____
8. Are there tasks taught that are never mastered at school or during the first enlistment? YES_____ NO_____
9. If "YES", describe.____
____
10. Does training need to be more realistic? YES_____ NO_____
11. Is there proper explanation of training goals (proper motivation of trainees)? YES_____ NO_____
12. Is there a danger of negative transfer from training to operational performance because training scenarios don't change? YES_____ NO_____

IMPEDIMENTS TO TRAINING

1. Do training media problems (availability of films, tapes, playback equipment) limit training? YES_____ NO_____
2. Is transportation to training locations a problem? YES_____ NO_____
3. Is trainee resistance to training a problem? YES_____ NO_____
4. Is supervisor resistance to training a problem? YES_____ NO_____
5. Is command resistance to training a problem? YES_____ NO_____
6. What other impediments exist to training?______________________________

____

____